METAL

PROGRESS

FEBRUARY
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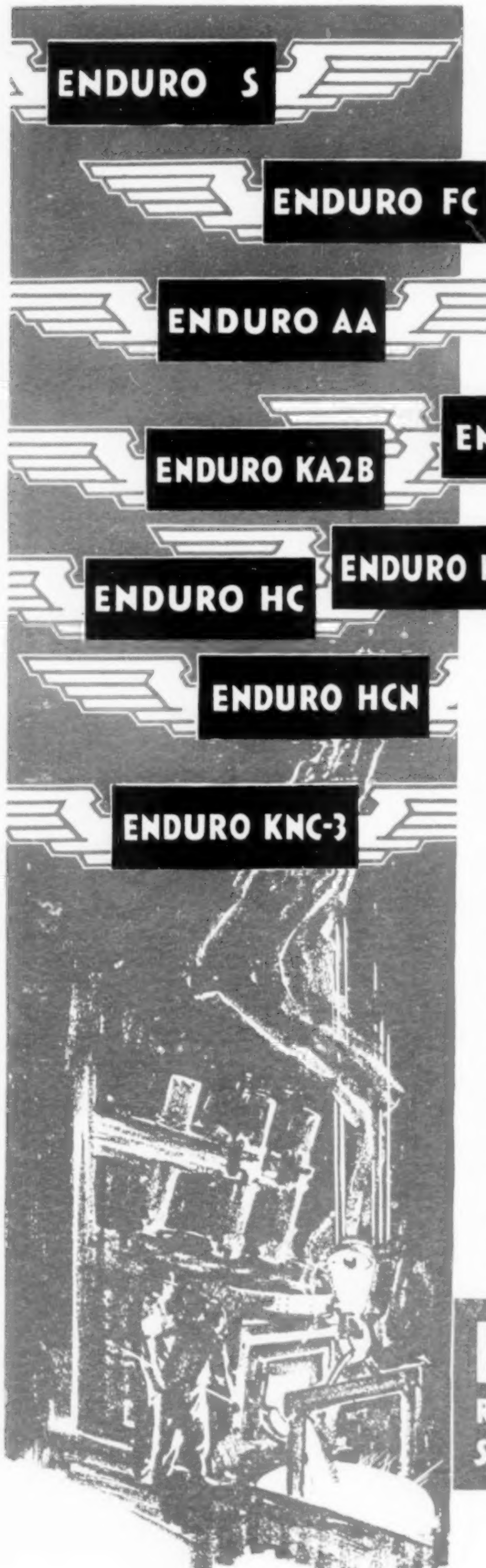

ENDURO...

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The day has passed when industry need struggle with stainless steel of a single analysis—nor is it now necessary to adapt processes and to change products on account of the unchangeable qualities in the steel itself.

Research has changed all this. Republic now offers Enduro in ten grades—a grade to meet every need—a grade suitable where corrosion resistance must be combined with strength and toughness—a grade that machines freely—a grade suitable for deep drawing—a grade for welded fabrication—a grade to withstand oxidation at extremely high temperatures, and others to meet certain specific requirements.

Tell us your problems and we will tell you what Enduro Nirosta can mean to you in terms of better products and better profits.

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REPUBLIC'S PERFECTED STAINLESS STEEL

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CENTRAL ALLOY DIVISION
REPUBLIC STEEL CORPORATION
MASSILLON, OHIO

METAL PROGRESS

Californians, Inc., Photo — San Francisco Skyline

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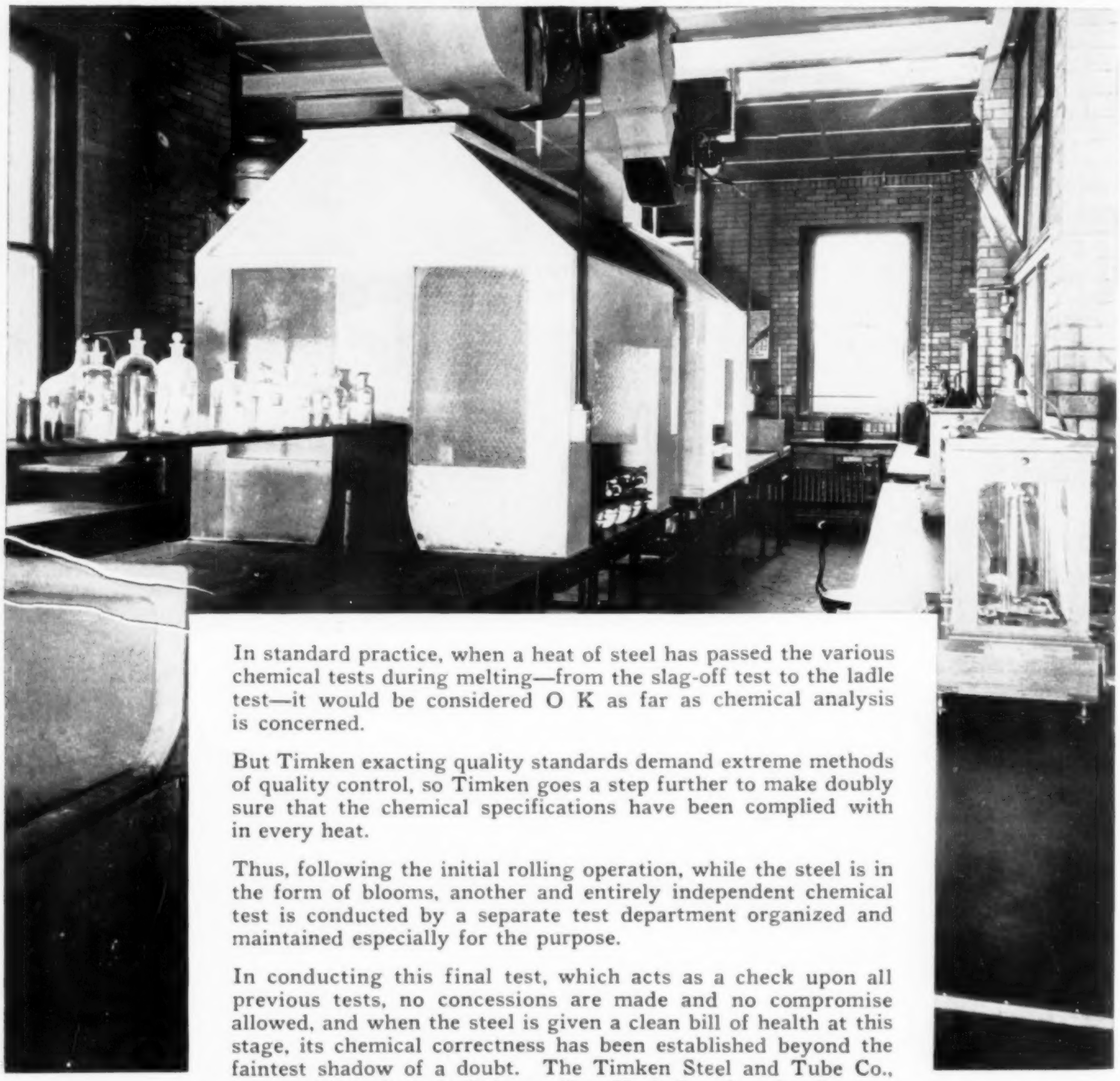
Ernest E. Thum, Editor

Timken Steel *is* Double Checked *to* Insure Chemical Correctness



In standard practice, when a heat of steel has passed the various chemical tests during melting—from the slag-off test to the ladle test—it would be considered O K as far as chemical analysis is concerned.

But Timken exacting quality standards demand extreme methods of quality control, so Timken goes a step further to make doubly sure that the chemical specifications have been complied with in every heat.

Thus, following the initial rolling operation, while the steel is in the form of blooms, another and entirely independent chemical test is conducted by a separate test department organized and maintained especially for the purpose.

In conducting this final test, which acts as a check upon all previous tests, no concessions are made and no compromise allowed, and when the steel is given a clean bill of health at this stage, its chemical correctness has been established beyond the faintest shadow of a doubt. The Timken Steel and Tube Co., Canton, Ohio. Detroit, Chicago, New York, Los Angeles, Boston.

TIMKEN
ALLOY STEELS

UNIVERSAL SCREW POWER TESTING MACHINE

Three Rotating Reversed Screw Type

U. S. Patents
Feb. 16, 1926
Jan. 28, 1930
British Patent
July 29, 1926

CAPACITY
300,000 LBS.

Plate No. 887 *Telegraph: Thebaneton*

DESCRIPTION

TESTING MACHINES of 300,000 pounds capacity are in considerable demand by steel mills, college and commercial laboratories. Highway laboratories find it advisable to purchase this or a larger capacity machine to test 6 x 16-inch cylinders or blocks of concrete. Steel mills can test good-size bars without reducing the section. Other laboratories find it convenient to test wire rope, chain, pipe or tubing, welded sections, columns, etcetera.

This machine embodies the improved features of Riehle design such as the three rotating reversed screws, automatic hydraulic recoil, fully enclosed automobile type six-speed transmission and a full and one-fifth poise so arranged that no parts are added to or removed from the weighing beam to change its range.

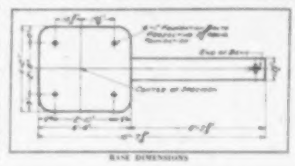
It can be operated to best advantage if it is located in a pit about 18 inches deep. The table top will then be about 3 feet above the floor. If, however, the machine is to be placed on an upper floor, or if it is not desired to cut such a pit, the machine can be operated with equal satisfaction by building about the machine a platform 18 inches in height.

In either of the above types of installation the height of the beam and operating levers will be most convenient for the operation of the machine and the handling of specimens.

Accuracy—This machine is accurate to plus or minus one-dial division (10 pounds) up to 10,000 pounds capacity. Above 10,000 pounds capacity it is accurate to plus or minus one-tenth of 1 per cent.

Standards Met—A. S. T. M.

Standard Equipment—1 set (1) large V-grips; 1 set (1) small V-grips; 1 set (1) flat grips; 3 sets (4 per set) grip liners; choice of 1 upper solid compression tool and 1 lower compression tool or 1 upper spherically seated compression tool; 1 upper and 2 lower transverse tools; 1 can Alemite grease; 1 Alemite gun; 1 can paint. A suitable constant speed A. C. motor only is supplied as standard equipment. If a D. C. or a special A. C. motor is desired, either will be furnished at additional cost.



BASE DIMENSIONS

DIMENSIONS and ADAPTATIONS

Extreme height	10 ft. 5 in.	Tensile specimens	
Extreme length	10 ft. 7½ in.	Round	up to 1½ in.
Extreme width	4 ft. 0 in.	Square	up to 4 in.
Height of table above base	4 ft. 5½ in.	Flat	4 x 4 in.
Motion of pulling head	3 ft. 1 in.	Compression tools	11 in. diameter
Maximum distance between heads for tensile testing	2 ft. 1 in.	Compression specimens	2 ft. 9 in.
Distance between screws	17½ in.	Power required	7½ H. P.
Transverse specimens	11½ in. wide x 3 ft. 9 in. long	Shipping measure	275 cu. ft.
		Shipping weight	18,400 lbs.

Issued 1-30-31 *Page U-8*

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YOU'LL find many features in the new Riehle Catalog—just gone to press—that have never before been incorporated in any testing machine catalog. • Letterhead size to fit your files—loose leaf so it can be perpetually alive—leather bound to protect its pages—list prices so that you can know approximate costs—sectional indexing so that machines of special use in a particular industry are grouped together—a fully cross-referenced index for your convenience in locating the machine you seek—blueprints of base dimensions and foundation requirements—statements of accuracy, sensitivity and standards met—complete descriptions and operations, and dimensions and adaptations—standard equipment with each machine. • • • These, and many other features not mentioned here for lack of space, make the new Riehle catalog one you'll want in your files. It is complete in every detail. • Reserve your copy now; it will be forwarded as soon as it comes from the press.

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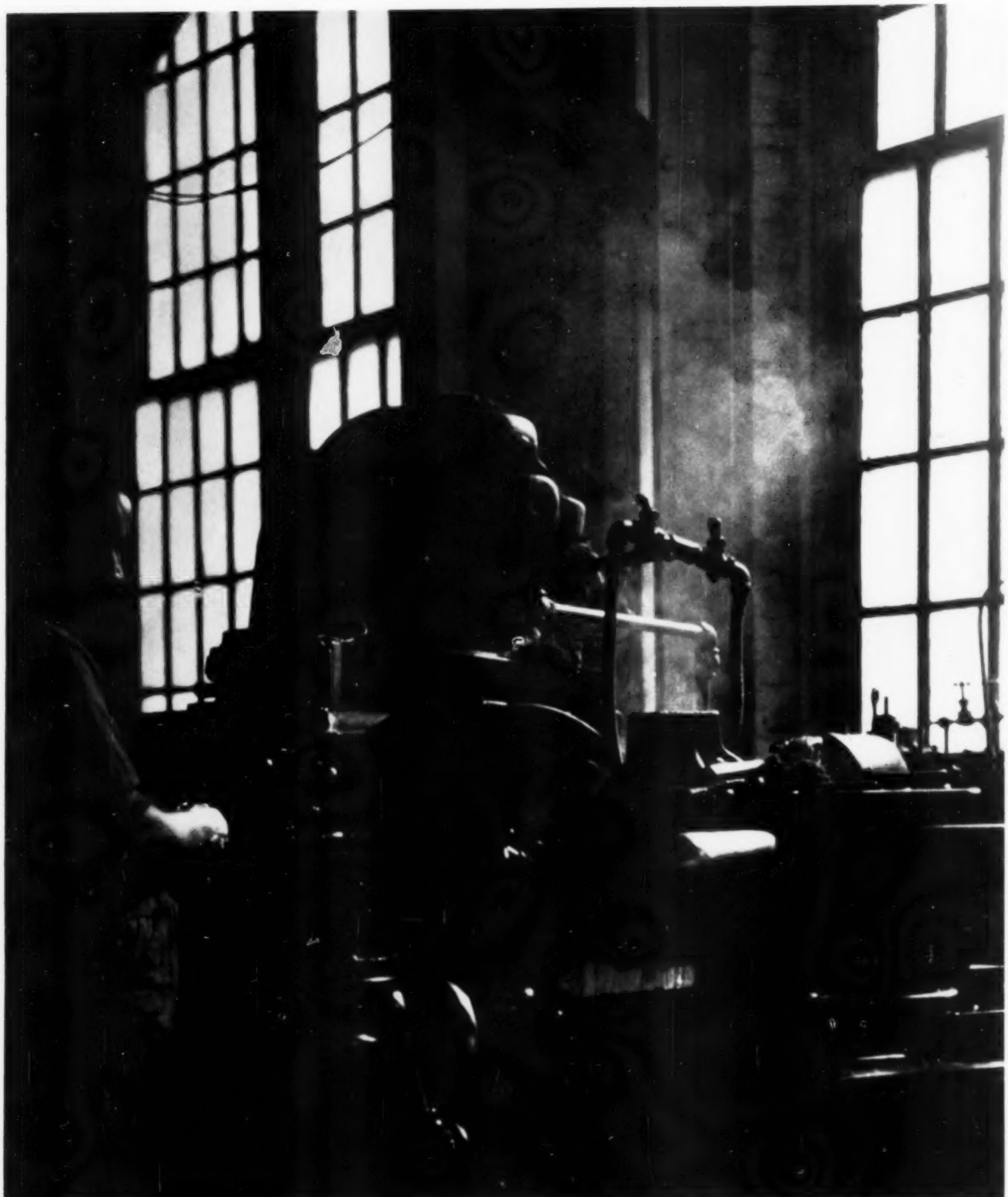


Photo by John P. Mudd

In the Machine Shop at Midvale

Steels

for

AMERICAN AUTOMOBILES

Model 1931 . . .

A TOTAL OF 69 steels is listed in the 1930 handbook, Society of Automotive Engineers. The question naturally arises, "Why are so many different types of alloy steel necessary?" As far as I can see, the answer is that metallurgists have their preference from close association with steels they have worked with, modified by the sales efforts put forth by the various alloy companies. Naturally, the writer has his own hobbies in the use of alloy steels but is frank to admit that other types will give perfect satisfaction when used in corresponding places. Right here, I want to suggest keeping the number of types of steel as low as possible. By doing this, the heat treating department can be laid out with fewer units, the inspectors become more efficient, and the furnace equipment has longer life as it is not necessary to change temperatures continually. In addition, purchasing is much more economical.

Perhaps the best way to show the uses of steel in an automobile is to analyze the various units of a car, giving the steel specified and the heat treatment. Let us start with the motor.

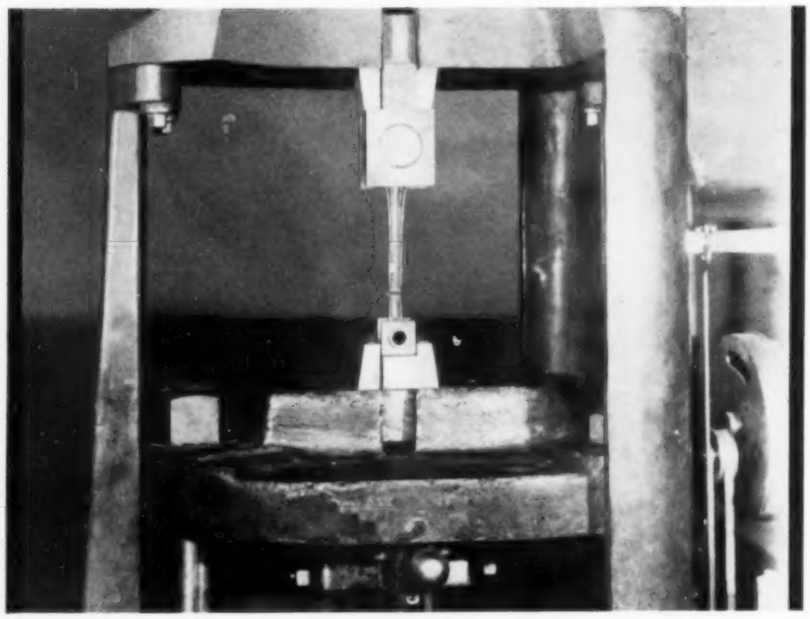
The crankshaft is a heavy drop forging, usually made from S.A.E. 1050. It is heat treated to Brinell 250, and has to be very carefully handled to make sure that the bearings are uniformly hard. The past three years have seen the development of an alloy crankshaft that does not require any treatment other than normalizing after forging; it is claimed that the extra cost of alloy steel is saved by easier machining and fewer straightening operations, but there is a great diversity of opinion among the forging companies regarding its use.

Connecting rods are usually made of drop-forging steel S.A.E. 1040; a fairly high carbon is used in order to give the required rigidity and at the same time keep the weight down: these should be normalized after forging and then heat treated to Brinell 179-197. Uniform structure is required for rifle boring the rod for proper lubrication of the bearings; hard spots result in the drill running off center, either spoiling the rod completely or giving a non-uniform wall thickness that makes the rod unsafe to use. Alloy steels of the 3200 series and also of the normalizing type spoken of above are sometimes used.

Piston pins are always carburized. A pronounced difference of opinion exists, and commonly used steels are S.A.E. 1020, 4615, and 6115. Pins must be extremely hard and strong enough to withstand the very severe reversals of stress in a high speed motor. Soft spots cause seizure, which may wreck a motor.

By J. M. Watson

Abstract of Paper for Western Metal Congress



In This Combination of Parts, a Tension Test Is Made Simultaneously on Connecting Rod, Piston Pin and Cap Bolts. No failure in any part is permitted under 17,500 lb.

Exhaust valves are specialties made of several different types of steel resistant to warping and scaling at high temperatures. They are practically all of some type of silicon-chromium steel.

Steel used in valve tappets or lifters varies a great deal depending on the design of the motor. Chilled cast iron or carburized S.A.E. 1020 steel is used in the mushroom type of tappet. In the lifter type, the part has to withstand not only an impact but also rolling friction and must be extremely hard, and S.A.E. 52100 (ball bearing steel) is the most popular. Rockwell C63-66 is obtained by careful heat treatment.

Camshafts are almost universally drop forged of S.A.E. 1020. They require very careful heat treatment in order to refine the core and get an extremely hard case. A tubular camshaft with the cams held in place by copper brazing was described at the National Metal Congress in Chicago last fall.

In cars where pumps are used to circulate the water system, a great difference of opinion exists regarding the type of steel to be used; this varies from carburized S.A.E. 1020 up through the stainless and nitrided steels. All seem to give satisfaction in their respective applications.

This covers the most important parts of the motor, so let's pass on to the transmission. There are two very distinct schools here, one favoring the high carbon oil quenched and the other the carburized gear.

In the high carbon field, there are three types of steel that predominate; the chromium steels of the 5100 series, the chromium-vanadium or 6100 type, and nickel-chromium of the 3200 series. All require careful treatment before machining; a combination normalizing and annealing process consuming about seven hours is necessary. It is a good plan to quench them in water, as this loosens the scale almost completely. Brinell hardness can easily be held between 187 and 207, which gives excellent tooth cutting properties.

There are three methods of hardening gears after machining and these depend upon the tooth pressures set up by the design of the transmission. (a) Straight quenching; here the gears are heated about 25° F. past the critical and held for sufficient time for the structure to become uniform and then quenched in oil or water, depending on the carbon content of the steel. (b) Gears are brought up to temperature as before and then transferred to a cyanide pot at a slightly higher temperature, held from 2 to 4 min. and then quenched in oil; this is known as the cyanide dip treatment. (c) Gears are immersed in a cyanide bath, brought up to the required temperature, held for approximately 15 min. and quenched in oil. All types of treatment must be followed by a draw at 350 or 400° F. to relieve the quenching strains.

Coming now to the second classification of transmissions containing carburized gears, the parts are ordinarily made from some type of nickel steel: 3½%, 5%, and the nickel-molybdenum steel, S.A.E. 4615. These types of steels are used where the loads are high. Of course, all of them require refined core as well as case. The new free wheeling transmissions are all being made of carburized nickel steels at the present time.

The front axle I-beam is a heavy forging usually of S.A.E. 1040, Brinell about 223. The

writer believes that on all such important units, the forgings should be normalized in order to get the steel in a condition to respond to its subsequent treatment uniformly. In the past two years great progress has been made in the automatic quenching of these axles, which keeps the forgings true to form. It saves the labor for straightening the axles, and avoids the undesirable stresses set up by cold straightening. Front wheel brakes have increased tremendously the torsional stresses on the section of the I-beam between the spring seat and steering knuckle, and this has been reflected back to the heat treatment.

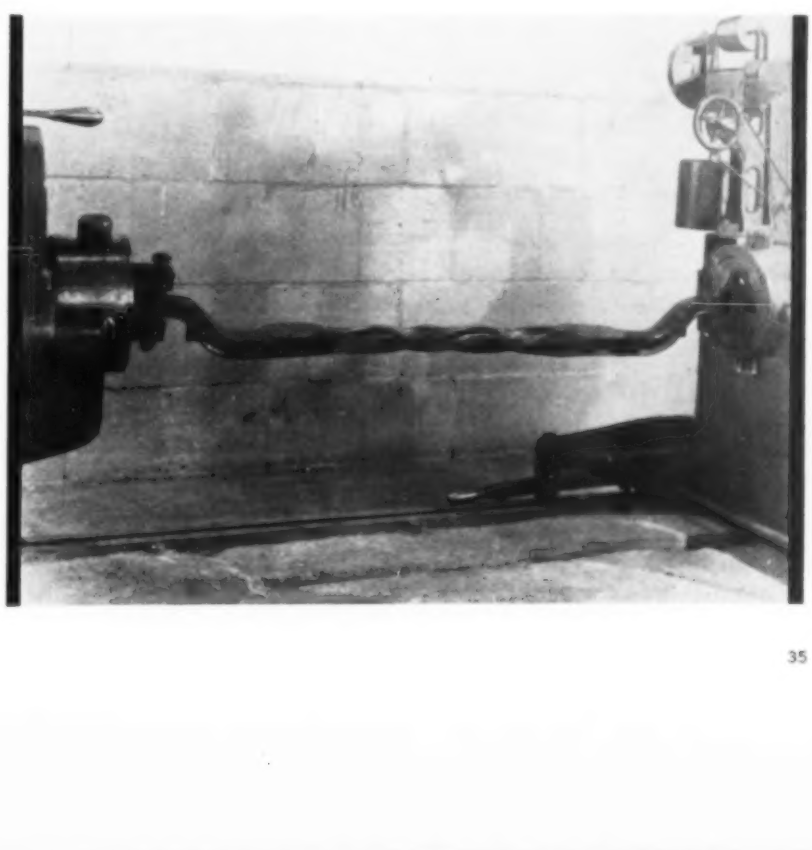
Perhaps the most important forging in the whole car is the steering knuckle. The entire safety of the car and its occupants rests on this one piece, for if a failure occurs, the control of the car is lost and only wonderful quickness and luck can prevent an accident. For the above reasons, alloy steels have come into almost universal use for these units. They must be sturdy; the engineers increase the weight rather than take a chance on safety. Chromium-nickel steels (S.A.E. 3240) and chromium-molybdenum of the same carbon range are extensively used; some of the higher manganese steels are also being tried. Here again, it is imperative that extreme care be taken in heat treatment, and a normalizing treatment is highly recommended. The Brinell should be about 250.

The steering knuckle pivot or king pin is also an extremely important unit. It has to be tough (as it is subjected to shock) and it must be hard (Rockwell C62 at least) as it meets with rolling friction under heavy loads. Here again alloy steels predominate. 3½% nickel, S.A.E. 2315, chromium-vanadium steel S.A.E. 6115, and nickel-molybdenum S.A.E. 4615 have been successfully used. Many metallurgists specify detailed treatments on this part, giving temperatures for refining the case and hardening the core. In addition, some have specified that the case must crack in six places before failure takes place under a transverse load. Before the advent of four-wheel brakes, carbon steels were extensively used and can be at the present time, providing the piece is of sufficient size and properly heat treated to withstand the loads met with.

The universal joint or propeller shaft, which connects the transmission and rear axle, is a unit that has to withstand very high torsional stresses. A speed of 3,000 r.p.m. is not at all uncommon in present day cars. There are so many designs of this unit that I cannot give detailed steel specifications. The flanges are nearly all made from carbon steel forging, S.A.E. 1035, heat treated to a Brinell of approximately 200. The internal parts of the joints are highly stressed and require high grade steels carefully heat treated. There is the same division of opinion regarding high carbon alloy steels and the carburized grades spoken of when discussing gears.

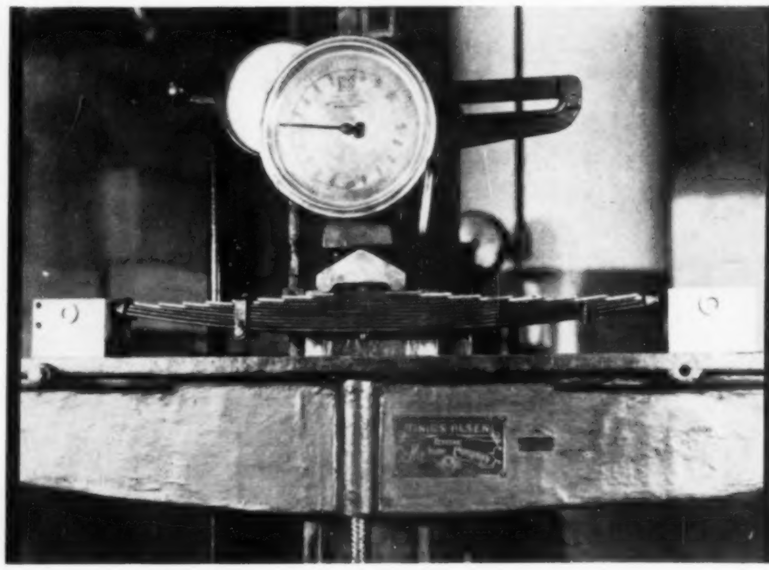
In the rear axle are found the differential gears and the drive shafts, all of paramount importance and requiring careful study.

The rear axle drive shaft has to stand up under very severe torsional loads and also very high shocks, as when the car is stuck and the clutch is engaged with the motor running at high speeds. Naturally, alloy steels are the most popular. Chromium steel with nickel



Torsion Test on Front Axle I-Beam. Ends are fixed in steering knuckle pivot pins, which must be able to twist axle as shown. Hupp specifies a yield point in torsion of more than 20,000 in-lb., and a 360° twist before any crack appears in any part.

A Good Spring Must Take a Reverse Camber Without Permanent Set or Failure. Fiber stress in main leaf when bent as shown is approximately 110,000 lb. per sq.in.

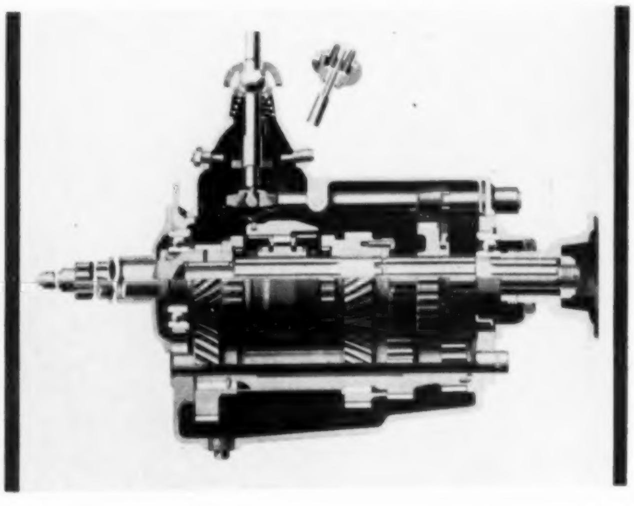


(S.A.E. 3240), with molybdenum (S.A.E. 4640), and with vanadium (S.A.E. 6140) are extensively used. Some metallurgists are now using one of the new medium manganese steels.

These steels should be heat treated to Brinell 315 and elastic limit in tension of 150,000 lb. per sq.in. or more.

The differential ring gear and pinion are also subjected to heavy loads and must be hard and tough. Here again the most popular steels are S.A.E. 2315, 2515, 4615, and 6115 with the first three predominating. The ring gear, being large in diameter and comparatively thin, presents a problem in quenching, for if it is not flat within a thousandth or two, disagreeable noises are produced when assembled in a car. After carburizing, ring gears are usually cooled in the pot, reheated and quenched in a press under heavy pressure. The fixture on the press is so designed that the gear is held flat and the oil covers the gear through a great many small openings. Even with this precaution, it is necessary to lap the gears and then match gears and pinions in order to secure satisfactory performance.

The side gears in a differential are not so highly stressed and therefore are made of either S.A.E. 1020 steel or a 1½% nickel steel.



All of the above units have to do with the power producing or actual locomotion of the car, but the riding qualities of a car affect the sales to a very marked degree and this brings us to the springs. There are several types of steel used here:

1. S.A.E. 1095, a straight carbon steel with carbon from 0.90 to 1.05%
2. S.A.E. 9250 and 9260, a silicon-manganese steel
3. Chromium-silicon-manganese, with no S.A.E. number, but with carbon range as above
4. S.A.E. 6150, a chromium-vanadium steel
5. Chromium-manganese steels, with no S.A.E. number but with carbon ranges as above.

Chief Requirements of Leaf Springs

It would start a battle royal to try to pick the best steel. There are many factors entering into this problem, starting in at the steel mills and going all the way through spring plants up to the automotive engineers. Of course, the chief requirement is resistance to fatigue. The stresses in springs are necessarily high, and care must be taken in treatment. The pieces are so long and thin that warpage is serious and here again quenching fixtures are required to produce a satisfactory product. Many engineers use what is known as a composite spring

Sectional View of Century Eight "Free Wheeling" Transmission and of Hupp Six-Cylinder Engine Indicates the Number and Variety of Parts Required in the American Automobile, Model 1931.

— an alloy steel in the main leaf (the one that has the eyes rolled on the ends and takes the torque in driving) and carbon steel in the remainder. A spring must be able to bend so that the leaves have a reverse camber in them without taking a permanent set, and must also give satisfactory performance under a car without failure or setting for at least a year. They are usually treated to Brinell 450.

I have refrained from mentioning bolts and studs used in the various units since this class can be covered collectively. They fall into three groups:

1. Those which are merely a necessary evil in holding two pieces together and of which no especial strengths are required. These are made of a bessemer screw stock, S.A.E. 1112; if some small strength is necessary, S.A.E. 1120 can be used.

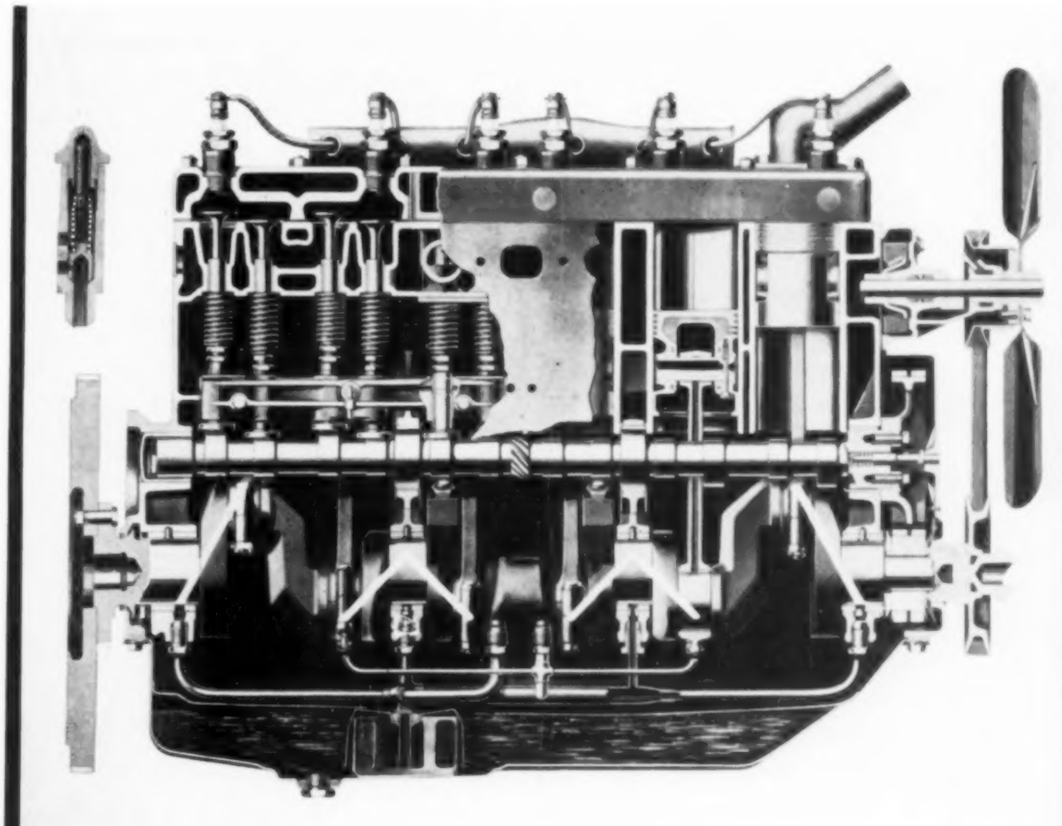
2. For those which must withstand some loads, S.A.E. 1020 is used.

3. Those which come under the head of high duty studs or bolts. Alloy steels are extensively used, the most popular being S.A.E. 2330 and S.A.E. 3130. These types of alloy steel will give strength up to 110,000 lb. per sq.in. very easily.

A controversy has been going on for several years as to the relative merits of milled-from-bar material and the upset head. Companies making the latter type in carbon steel have adopted a carbon range of 0.27 to 0.37%, as it seems to work in the upsetters better than bessemer screw stock. Upset bolts should be heat treated to relieve internal strains. Carbon steel studs should have a Rockwell B80 to 90; alloy material B95 to 105 hard will prove satisfactory.

Deep Drawing Stock

This covers the material used in a car outside of sheet metal work and stampings. So far as I know, there are no satisfactory standards that can be generally used because there are so many factors entering into this operation of deep drawing. The design of the piece, the size, speed and power of the presses used, the drawing compound or lubricant used, all have a marked effect on the number of defectives produced. In each individual plant it is possible to establish relations between laboratory ductility tests and plant usage, but the same tests will not work in another plant even in a corresponding part.



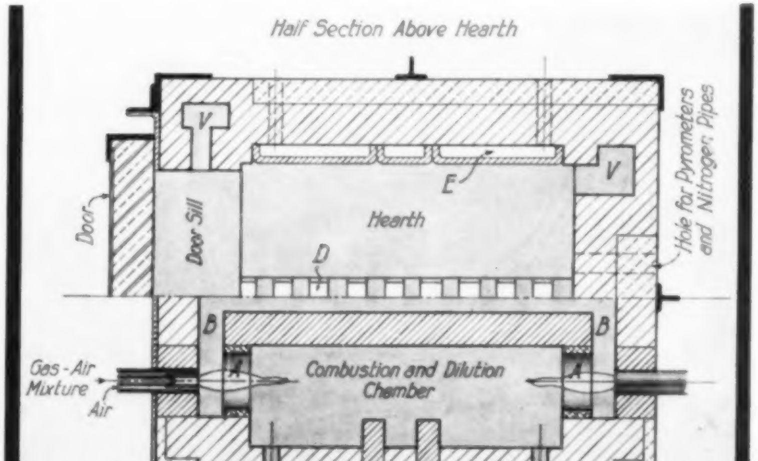
Low Temperature Gas Furnace for NITRIDING AND DRAWING

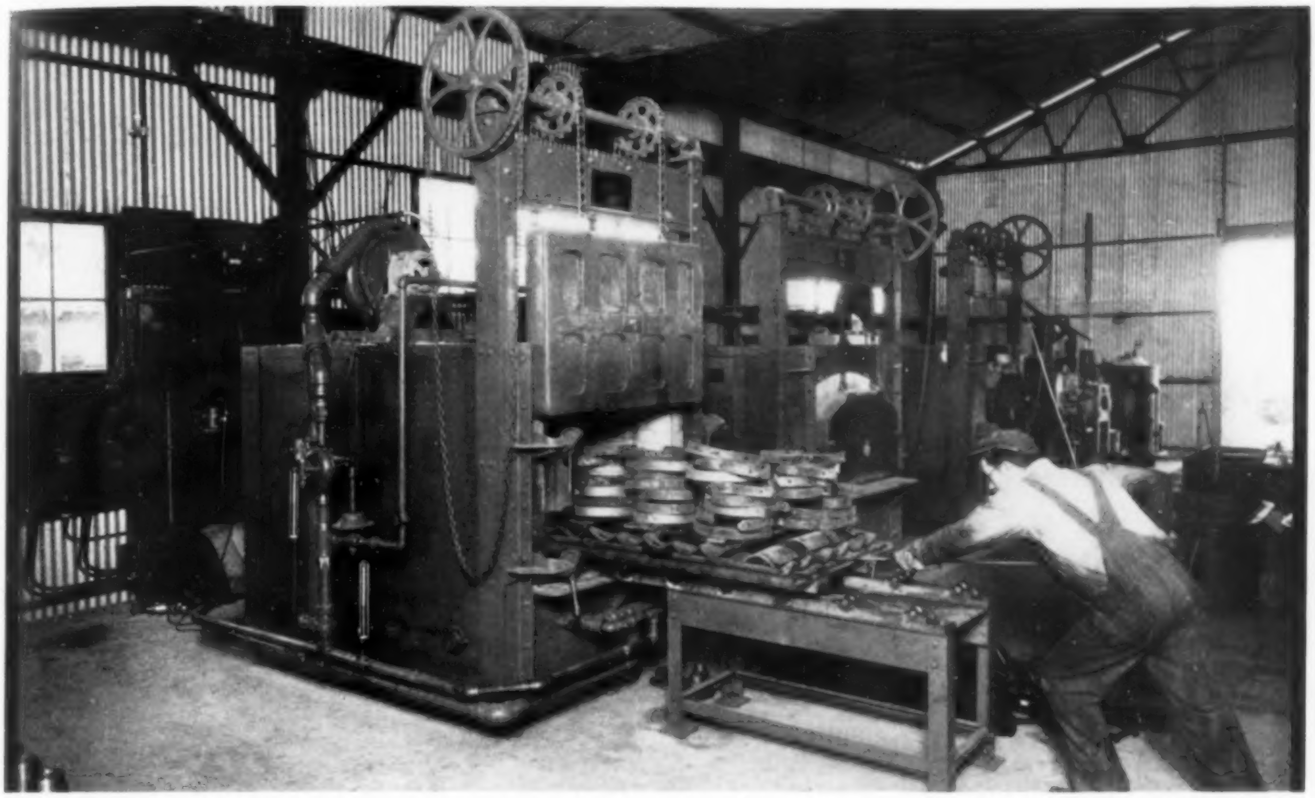
By James H. Knapp
Abstract of Paper for
Western Metal Congress

IT IS DIFFICULT, if not impossible, to operate a standard type of gas furnace at nitriding temperatures. Semi-muffle furnaces are quite suitable for operating at 1,200° F. and up, but nitriding requires a long heat at uniform temperature in the neighborhood of 960° F. A satisfactory furnace for the latter duty must introduce two new features, (a) some method of reducing the high spread between flame temperature and temperature of work and (b) some method for uniform and rapid circulation throughout the entire chamber. The latter will not only give uniform temperature but economical heat transfer by convection between furnace atmosphere and work to be heated. (It should be remembered that a radiant heat furnace, while ideal for high heat furnaces, is impracticable for temperatures as low as 800 or 900° F.)

Furnaces which have solved these problems have been in continuous commercial operation for a period of six months. The one illustrated has a 36x60-in. hearth, 24 in. high. On nitriding it requires 75 cu.ft. natural gas per hour, gas having a heating value of 1,150 B.t.u. per M. Fuel costs in the Los Angeles region are therefore on the order of 4¢ per hr.

The problem of avoiding hot spots near the burners is solved in the following manner: A mixture of gas and air properly proportioned for perfect combustion is discharged through the inner pipe (shown diagrammatically in the plan) and burns in a cone off the end of a second pipe prolong. A focus of high temperature is





overcome by blowing cold air through a larger surrounding pipe, in an annular sheath surrounding the flame. The burning gases mix with the cold air in this sheath, diluting them and reducing the intensity of heat.

Four of these burners are supplied, two on each end of the furnace. The stream of gas and air passes through a chamber *B* and blows through a larger hole *A* in the secondary wall into the combustion chamber underneath the hearth. *B* is a portion of the flue system, and the injector action of the flame at *A* creates a "minus pressure" in the passages under the hearth, thus drawing the gases in the main heating chamber downward through a series of holes *D* in the center of the hearth. The course of the gases is from the combustion chamber up along both sides of the hearth behind tiles *E*, thence turning sharply down toward the centerline of the hearth, through vents *D* into passage *B* and out through four vents *V* in rear wall and door jambs. Operating pressure in the furnace may be controlled by dampers in these vents.

Burned Gases Are Mixed With Excess Air in Dilution Chamber, Come up Through Tiles at Sides of Heating Chamber and Are Sucked Down Through Holes in Center of Hearth. Gas supply is regulated by valves at side of furnace and mixed with proper amount of air for combustion. Diluting air is controlled by gate valve and manometer on secondary pipe.

Uniformity of Temperature

To study the uniformity in temperature, a thermocouple was placed through the pyrometer hole in the rear of the furnace, and a second couple was placed on the hearth of the furnace; the control couple was in its normal position through the center of the roof of the furnace. With a full load in the furnace and a temperature of 960° F., the two thermocouples connected to the two-point recorder drew a straight line, indicating no difference in temperature between them, after the furnace and the load had reached the control temperature.

The half tone shows a motor-driven blower mounted on top the furnace casing, which furnishes air for the operation of the unit. The blast is divided by the Y connection near the blower, one portion going to the gas and air mixer, and the remainder to the air cooling or diluting system.

Gas and air are apportioned automatically in a mixer of the McKee type, complete with a regulator which reduces the gas line pressure to atmosphere. *(Continued on page 156)*

A review of "Recent Developments in Corrosion Prevention of Ferrous Metals" has been prepared by the authors for presentation at the Western Metal Congress. It summarizes the principal studies published during the past year or two, paying particular attention to the oil industry. The last mentioned portion of the paper is reproduced herewith.

. . . Combating CORROSION in the Oil Industry

By V. V. Kendall and F. N. Speller

ORGANIZED cooperative work on corrosion has increased considerably both here and abroad during the past five years. It is still easier to enumerate the problems to be solved than the work already accomplished, but it may be encouraging to review briefly the large savings that have been effected so far.

1. The life of steel exposed to atmospheric corrosion outdoors has been increased from two to five times by the addition of 0.25% copper, at an average increase in cost of $3 per ton (about 5%).

2. Steam boiler and hot water piping corrosion in large stationary plants and even in locomotives may now be kept under control, and sometimes practically eliminated, by efficient de-aeration and water conditioning.

3. Corrosion from refrigerator brine and in circulating water systems has been brought under close control by the proper use of sodium dichromate and other film-forming inhibitors, at a very small cost compared with the large annual saving in the durability of the equipment.

4. Much has been accomplished toward a better understanding of the complicated soil corrosion problem, and toward the manufacture and application of more durable coatings for use underground.

5. Better paints and lacquers have been one of the most notable achievements of the past few years. About $100,000,000 is spent annually on coating materials for use outdoors. Recent developments in the manufacture of synthetic resins promise new coatings that are tough and resistant to many chemicals and yet not out of reach in price.

6. Protective measures have proven to be of vital importance to the profits of oil refineries. New resistant alloys, chemical treatment of the crude oil, and protective coatings have each contributed their share. The corrosion engineer has done no better work anywhere than with difficult problems in this field. For instance, a committee of the American Petroleum Institute states that a net saving of $24,160 per annum was obtained on a 10,000-barrel still by neutralization with ammonia and lime.

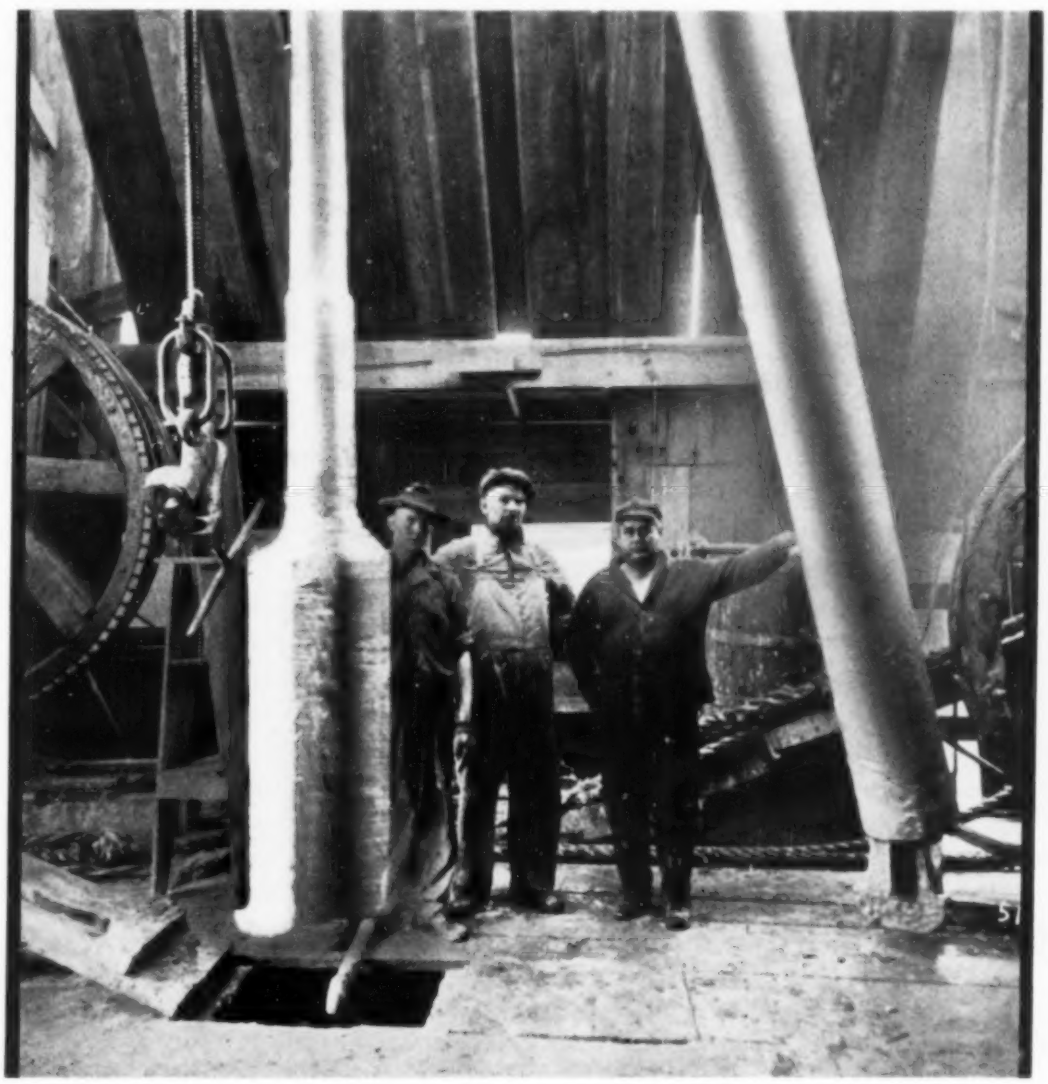
Annual losses in the oil industry, directly and indirectly due to corrosion, have been variously estimated from $125,000,000 upwards (about equivalent to one cent per gallon of gasoline produced at present). The figure is particularly difficult to estimate, but no one questions that the total is a very considerable sum. The

American Petroleum Institute has recognized this as one of the major problems of the industry and has recently organized two main committees to work out the best means of prevention. One of these committees deals with transportation and production problems (with the aid of a full-time salaried technical assistant) and the other handles refinery and marine problems. Probably 150 or 200 men in the petroleum industry are putting most of their time on this work. Companies producing machinery and materials used in the oil fields are probably doing an equal amount of investigative work.

The American Petroleum Institute has already done great service so far in analyzing the problem in its various phases; in fact, this organization is the largest cooperative force at present engaged on the corrosion problem. After a problem of this kind is thoroughly understood, its solution is usually not far away. However, only a small proportion of the preventable loss has been eliminated. Of course, the economic side of the corrosion problem must always be kept in view; the cost of prevention must be less than the loss directly and indirectly due to deterioration.

Corrosion in Producing Fields

In oil fields we find all classes of corrosion — atmospheric, soil, water and chemical attack (hydrogen sulphide in particular). In addition to the accelerating action of hydrogen sulphide upon the naturally severe corrosion by salt water from oil wells, corrosion is accelerated locally by the contact effect of dissimilar materials, including corrosion products, and by corrosion fatigue (that is, the combined action of stress and corrosion which is often illustrated



in the rapid failure of sucker rods). As a rule, rotary drilling muds fortunately exercise an inhibiting effect, so that very little corrosion fatigue has occurred in drill pipe. It is known that a finely divided inert material adsorbed on the surface of metal affords considerable protection. Thus, portland cement is a very effective protector against corrosive mine waters, even after the free lime and other more soluble constituents are extracted. The porous cement still protects the metal by maintaining an inert layer of oxygen-free water in contact with the metal. Work done by E. L. Chappell in the laboratory of National Tube Co. illustrates the similar protective influence of fine sand in different thickness. Bare steel, at the end of 20 days, was corroding at the rate of 1.7 mg. per day per sq. in. of surface. The corresponding figure for steel covered by 1/64 in. sand was 0.3 mg. and for steel covered by 3/16 in. silica was 0.05 mg.

Production problems have been reviewed in a comprehensive manner by the American Petroleum Institute subcommittee on production corrosion in a report rendered December, 1930. The most serious damage to oil well equipment seems to result from sulphur compounds (not yet isolated) in salt water. Protective coatings generally cannot be applied, but it is possible that a durable coating will yet be developed with sufficient flexibility and resistance to abrasion to stand a reasonable amount of rough handling and strain without fracture. Such a protective coating, organic or inorganic, would be very useful for the protection of sucker rods, tubing and casing. It would serve a useful purpose even after it had been partially destroyed, as the corrosion would be localized and the material could be reconditioned more easily. Corrosion fatigue is quite common near the upset ends of sucker rods, and this might be retarded by a flexible coating. There is every incentive to search for a better protection for steel under such conditions.

The injection of lime or sodium hydroxide

into the wells may be warranted in very severe cases, but as a rule the economic remedy will probably be found in the use of more resistant steels.

Service tests have shown little difference between the various grades of iron and steel tubing found on the market, although the addition of 0.75 to 1% copper has increased the life of tubing five to ten times in some locations where sulphuretted hydrogen is absent or very low.

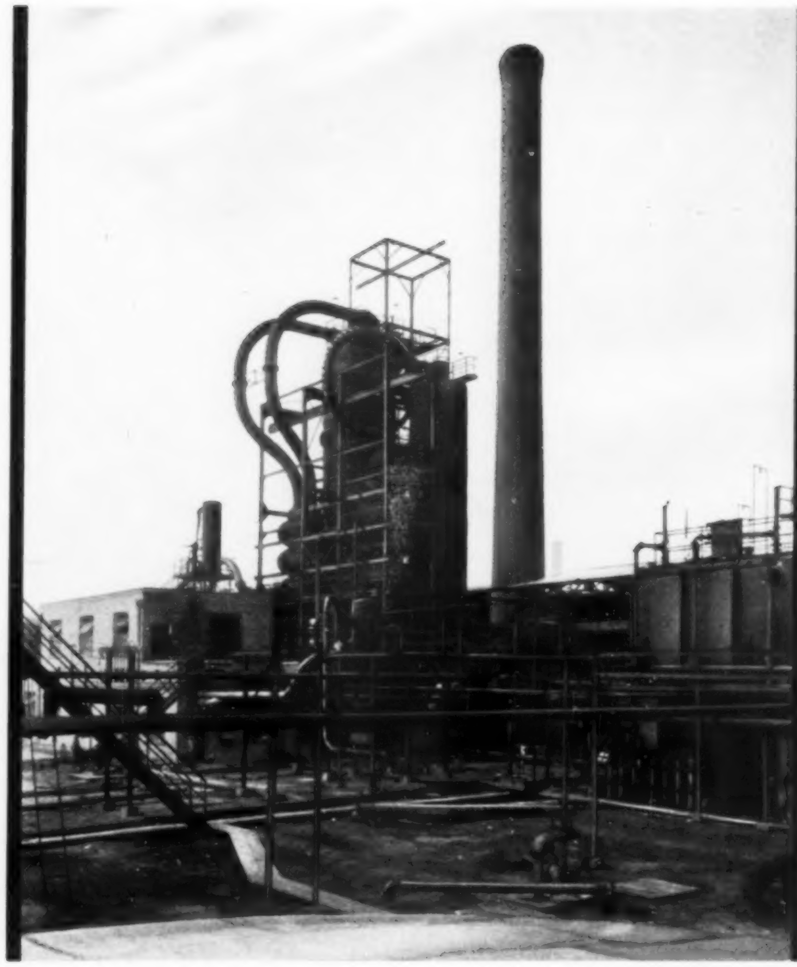
The subcommittee mentioned above has reported that black steel and wrought iron give almost equal service in most fields, that in most areas galvanized tubing is much better than plain steel or wrought iron, and that other ferrous tubing materials, such as ingot iron and copper-molybdenum iron, have not shown any superiority over steel tubing.

Evidently, then, for severe conditions we must look for a more resistant steel, reasonable in cost. Both chromium and aluminum tend to build up surface films that are relatively stable when exposed to sulphuretted salt water. It is known that steel with 5% chromium is several times as durable as carbon steel in the presence of corrosive sulphur compounds in pressure stills, and the addition of small amounts of aluminum with chromium in various proportions is being studied in steel for oil well equipment.

Development of the best and most economical low-alloy steel for such service will require considerable cooperative field work between manufacturers and consumers. For economic reasons, such an alloy should be standardized after sufficient preliminary work has been done. Low-alloy steels have already received considerable attention in the development of high tensile casing and drill pipe. It now appears that the question of additional durability must be given more consideration than it has in the past, and durability is an essential requirement (in addition to high phys-

icals) for casing, tubing and other equipment.

Service conditions vary so widely between different fields and in different parts of the same field that the problem is not an easy one to solve. Hot galvanizing is often worth while, especially when applied on copper steel, and should be more generally done. Portland cement lining for oil pipe has given good results for two years in gathering lines in Indiana, where there is considerable sulphuretted salt water.



Problems of refinery corrosion have also been analyzed in more detail by a committee of the American Petroleum Institute during the past year or two, and may be divided into (1) low temperature and (2) high temperature corrosion problems. Since very large quantities of oil are handled, considerable metal is wasted, even though the corrosion rates are comparatively low.

In distillation apparatus, hydrochloric acid (resulting from the decomposition of calcium and magnesium chlorides in the water) is mainly responsible for damage to condensers and other equipment in the low temperature range. This action is accelerated when hydrogen sulphide is present. Ammonia is the most effective neutralizing reagent under these conditions. Admiralty metal offers good resistance, but neutralization is also frequently required even when such alloys are used. Sometimes steel condenser tubes will give good service when the liquids are neutralized. Cast iron containing considerable nickel and chromium has given promising results, and may be found economical for use in valves and fittings, as suggested by Vanick and Merica, *Transactions*, A.S.S.T., Vol. XVIII, published Jan., 1931.

The action varies so much in plants operating with different crudes and under different conditions that no general rule can be stated. Selecting the most economical means of protection in refinery operation is a task calling for corrosion engineering, skillful experimentation, and use of all that can be learned about the many fatcors involved.

When cooling water is recirculated in condensers, corrosion may be inhibited by the use of sodium dichromate, to which a smaller percentage of sodium phosphate or sodium silicate may be added to advantage. The required amount of chemical depends mainly on the chloride content and temperature of the water, and must be determined for each installation, but the treatment is usually economical and might be more generally practiced. The average cost is about $250 per million gallons of fairly pure water per year.

When cooling water is run to waste, or reducing reagents are present, chromate treatment would of course be impracticable. Partial protection may then be obtained by the addition of lime, when the composition of the water lends itself to formation of protective coatings.

Oxidation of the metal on the fire side, and action of sulphur compounds in the

crude oil, is responsible for most of the deterioration of metal in high-temperature equipment in refineries.

No economical and practical method has yet been developed for the removal of sulphur. Effective remedial measures are:

1. Neutralizing with lime.
2. Using protective coatings (metallic and non-metallic). Lining reaction chambers with portland cement, concrete, or other silicious material has proven effective.
3. Using thicker metal.
4. Substituting a more resistant metal such as the well-known 18-8 chrome nickel steel. This has also been used as a liner.

Before adopting the first expedient (a neutralizing treatment) it is desirable to consider the possible detrimental effect of this material on the residual products. However, some high-sulphur crudes cause a penetration of 1 in. per year in some parts of the equipment, and then neutralization must be employed.

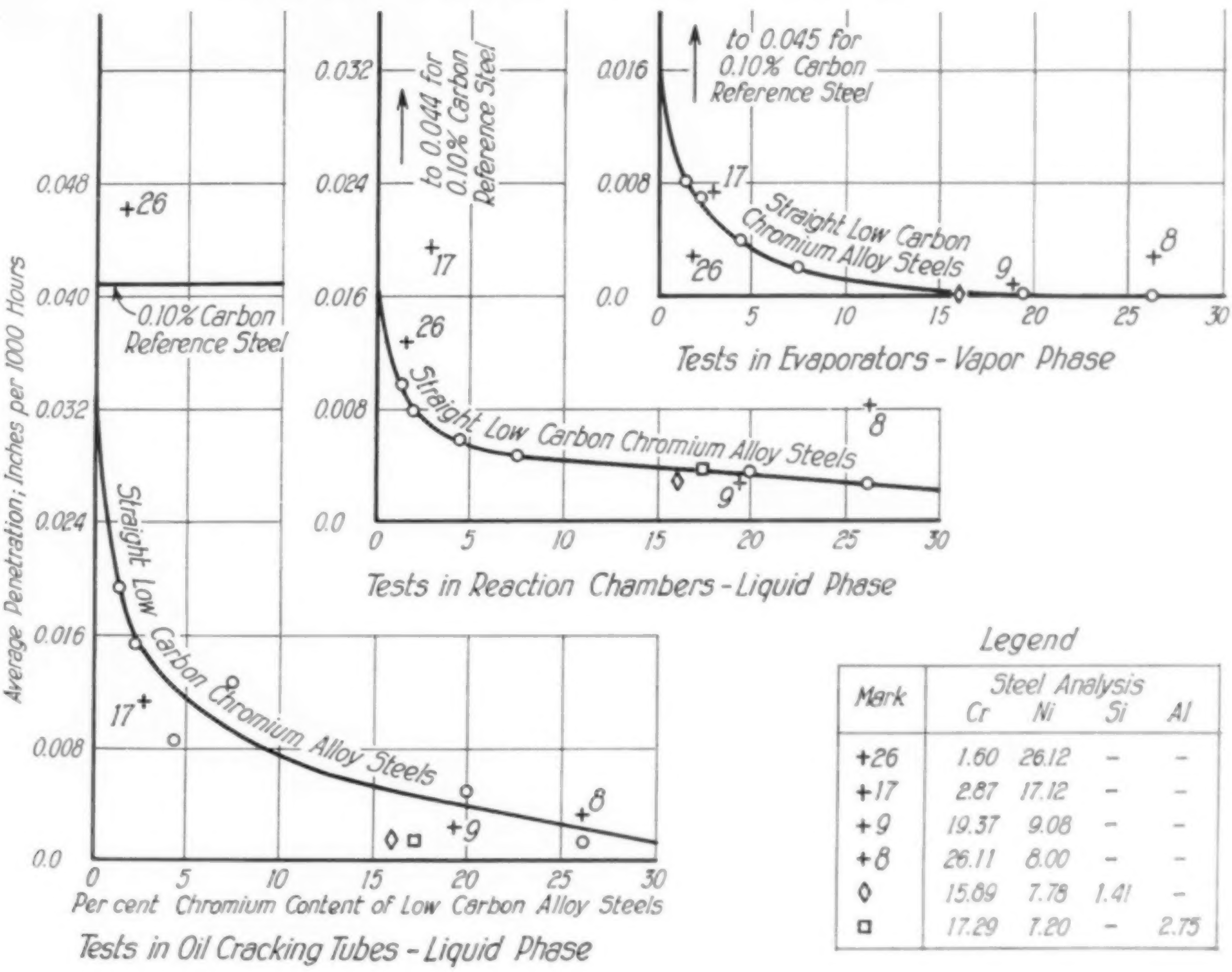
It is well known that much work has been done during the past few years on the fourth expedient listed above, namely, corrosion and heat-resisting metals. A summary of some of the results of corrosion tests on a series of small chromium and chromium-nickel steel heats prepared in the National Tube Co. laboratory is shown in the curves just below. Tests on these steels were made in oil refineries by eight cooperating companies.

Service Tests on Special Steels

The general conclusion drawn from these tests are:

1. The relative corrosion-resistant properties of metals exposed to oil refining conditions may be determined *(Cont. on page 113)*

Service Tests on Small Heats of Special Chromium Steels Made With the Cooperation of Eight Oil Refining Companies



Legend

Mark	Steel Analysis Cr	Ni	Si	Al
+26	1.60	26.12	–	–
+17	2.87	17.12	–	–
+9	19.37	9.08	–	–
+8	26.11	8.00	–	–
◊	15.69	7.78	1.41	–
□	17.29	7.20	–	2.75

Courtesy Allis-Chalmers Mfg. Co.

A Big Cupola Tap

Cupola Melting of . . .

HIGH TEST CAST IRON

By F. B. Coyle

Abstract of Paper for Western Metal Congress

FUNDAMENTALLY, gray iron can be considered a mixture of steel and graphite. Since the steel-like body contains an appreciable amount of silicon, it must be regarded as an alloy steel. It is, then, reasonable to state that three definite factors must affect the strength of cast iron:

1. Amount, size and distribution of the graphite.

2. Amount of combined carbon as cementite.

3. Amount of alloying elements present.

By proper regulation of these factors, the common gray iron of commerce, testing less than 30,000 lb. per sq.in., can be raised to a high grade (30,000 to 38,000 lb. per sq.in.), a "high test" iron (38,000 to 50,000 lb. per sq.in.), or a "high strength cast iron" (testing over 50,000 lb. per sq.in.). To produce the last-mentioned variety, it is necessary to resort to special processes and exact metallurgical control. High test iron with 38,000 to 50,000 lb. per sq.in. tensile strength can, on the other hand, be produced in any foundry if reasonable care is taken, and it has a broad field of usefulness. Consequently, this paper will confine itself to that variety.

Many investigations have determined that in high test cast iron the graphite particles must be small and evenly distributed, which, in practice, requires that the total carbon in the iron must be low.

Now, in order to obtain low total carbon without an "oxidized" condition in the iron, it is necessary to do four things: Use high percentages of steel scrap in the charge, use a minimum amount of pig iron, charge the various materials in proper order, and finally operate the cupola under approved conditions.

Amount of Steel Scrap used must be found by trial. Half steel will usually give from 2.75 to 3% total carbon in the iron. These carbon limits offer a broad range for the silicon; nickel and chromium raise the upper carbon limit to 3.15% and further broaden the silicon range.

The use of more than 30% pig iron in the charge will probably cause primary graphite in the form of developed flakes. (In some instances a European pig iron with total carbon 2.5 to 2.75% has been used.) The remainder of the charge other than pig iron and steel should be a good grade of foundry returns of known composition, preferably high test cast iron returns.

Order of Charging of materials has been debatable, but two general methods have been successful, one for intermittent and one for continuous tapping. For intermittent tapping from the cupola, the following order is good: (1) pig iron on coke, (2) foundry returns, (3) ferro-alloys (if any), and (4) steel.

If a pool of pig iron accumulates first, it contains sufficient silicon and manganese to deoxidize the remainder as it melts. When steel comes down last, it remains in contact with hot coke a shorter period of time than if otherwise melted, and less carbon is absorbed.

Charging Order for Continuous Tap

If molten metal is continuously drawn from the cupola, charge half of pig iron on coke and then charge the steel, remainder of pig iron, foundry returns, and ferros well mixed. This will insure sufficient silicon and manganese at all times in the continuously melting charge to prevent oxidation.

Oxidized Iron. It may appear difficult to oxidize in the presence of such large proportions of the reducing elements (carbon, silicon and manganese) as occur in gray iron. However, such a condition can occur in cupola-melted metal.

The fracture of oxidized iron is generally very hard, light in color, and granular in appearance. Combined carbon in such iron is very high; annealing decomposes little of it even at temperatures as high as 1,500° F.

Molten oxidized iron may appear brilliantly white and very hot, but it soon becomes pasty, sets quickly and lacks fluidity. It often sets on the sides and lips of ladles. While running over the spout, thin sparks ending in tongues are usually emitted perpendicularly to the surface of the metal, instead of the scintillations commonly observed. After such metal has been poured in molds and apparently solidified, some metal will rise up in the sprues, producing the "cauliflower effect."

Coke Bed. The height of coke bed above the tuyeres should be between 42 and 48 in. regardless of the cupola size. This is higher than generally used in ordinary gray iron practice. First charge about two-thirds of the required bed coke. After igniting well, a gentle blast is turned on until the bed is entirely burned through.

This thoroughly warms the entire stack of the cupola, which is essential in producing good hot iron, particularly on the first tap. During this period, much ash is blown up the stack, which is good, for it eliminates some sulphur which might be absorbed by the first charge during the soaking period to be described later.

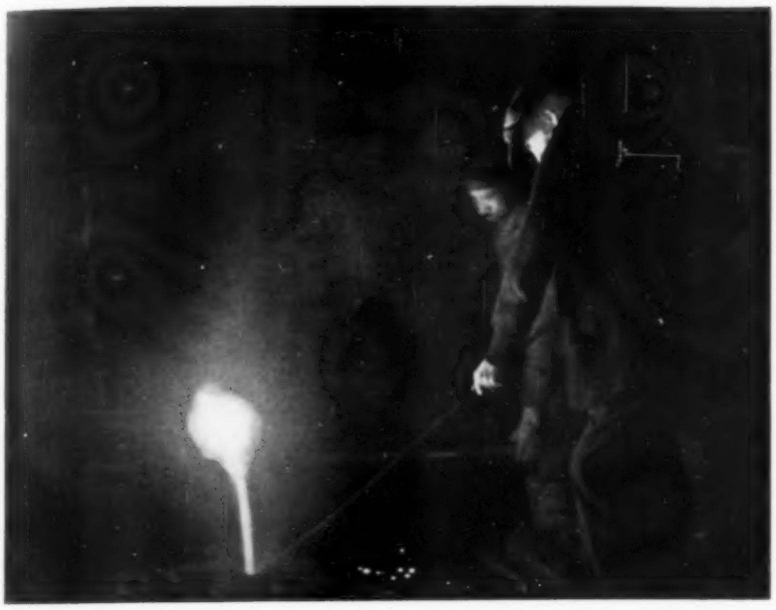
The balance of the bed coke is then charged. It is usual to sprinkle some limestone on the top of the bed. Then the metal charge is made in the manner previously described.

Metal Charges. It is surprising to note the varying weights of metal charged in various foundries. Charges in 66-in. cupolas varied from 2,000 to 4,000 lb., and in 72-in. cupolas from 2,000 to 6,000 lb. Data taken from 50 cupolas in successful production, using the procedure herein described, may be summarized as follows:

Diameter of Cupola	Charge	Blast Pressure
24 in.	500 lb.	4 in.
30 in.	650 lb.	5 in.
36 in.	900 lb.	6 in.
48 in.	1,800 lb.	9 in.
60 in.	3,000 lb.	12 in.
72 in.	5,000 lb.	15½ in.

Some operators use a first charge either smaller or larger than the succeeding ones, but this is of doubtful value.

Coke Charges. In order to obtain metal above 2,700° F. (when measured by an optical pyrometer), the subsequent coke to metal charges should be 7.5 or 8 to 1. A good grade of by-product coke is generally used, although



mercury or water pressure gage, and it is surprising how many do not use even this method.

Nevertheless, it is better to use the tools one has at hand than none at all. For this reason, the relation between blast pressure with 30% tuyere ratio and cupola diameter is shown in the tabulation opposite. These pressures have been and are being used with success.

When using a volume meter, it has been found that 30,000 to 33,000 cu.ft. per ton per hr. (with 30% tuyere ratio) is a safe amount to blow into the cupola.

Tapping. Time of tapping molten metal from the cupola is most essential in carbon control.

While melting all-steel charges in a cupola, it was found that it absorbed about 2% carbon as it melted and trickled down. Additional carbon was then absorbed while the metal collected and remained in contact with incandescent coke in the well, depending upon the length of time it remained there.

If the bed coke is the proper height above the tuyeres, iron should be seen trickling past the peep holes in 3 to 5 min., and if the tap hole is left open, iron should run down the spout 8 or 9 min. after the blast is turned on. The first charge of correct size will melt in 17 to 22 min., and subsequent charges in 12 to 15. However, this is not a definite set of conditions and varies in individual operations.

Slow melting may force two taps for the first charge in order to keep the carbon low. But if the weight of charges is as shown in the tabulation and other operating conditions are normal, a total carbon content between 2.75% and 2.95% should be obtained if each charge is tapped out as soon as melted. This will require logging the individual cupola and tapping out on a time schedule, but that is easy to do. A slightly higher or lower total carbon can be obtained by either raising or lowering the height of coke bed slightly.

Alloy Additions can be made either at the spout in the conventional manner or as alloy pig added with the charge in the cupola. Alloys, particularly nickel or nickel and chromium,

some operators are obtaining good success with low ash, low sulphur 72-hr. beehive coke.

Flux. Generally about 20 lb. of limestone per ton of metal is added on the top of the metal charge. Many individuals also add 5 lb. of soda ash.

Soaking Period. After the stack is filled to the charging door, the column should be permitted to stand for one hour. If the peep holes are open, the coke will remain incandescent and a slowly rising column of hot gas will preheat the first and second charge. This increases the temperature of the metal tapped — particularly the first charge.

Tuyeres. The area of tuyeres should be between 25 and 33% of the area of the cupola at the tuyeres. The writer has examined cupolas during the past six months with tuyere ratios varying from 1.2 to 1 to 15 to 1! If the tuyere area is too great, the velocity of the blast entering the cupola is low and proper air may not reach the center of the melting zone. If the area of tuyeres is too small, then the velocity of the blast may be great enough to produce a chilling effect on molten iron dripping down through the bed coke. A double row of tuyeres needs a column of bed coke so high as to cause excessive carbon absorption, which is fatal to the production of high test iron.

Blast. It should go without saying that the proper method of measuring blast is either by volume or by weight. However, few foundries use such methods — the majority still use the

produce maximum quality in high test cast iron. It is possible to reach the upper limit of strength in iron of greater density, hardness and resistance to wear, free from porosity, and at the same time maintain commercial machinability. Numerous examples of such combinations are shown under the list of applications tabulated.

Properties. In the carbon range 2.70 to 3.15%, high test alloy cast iron can be uniformly produced with the following physical properties in arbitration test bars:

Tensile strength	38,000 to 49,000
Transverse strength	4,200 to 5,600
Deflection	0.15 to 0.20
Brinell hardness	200 to 240

As an engineering material it has a very broad field of application, particularly for heavy castings. A comparison of properties obtained in locomotive cylinders weighing 12,000 lb. each, when made of plain iron and of alloy iron is given on the data sheet, page 81. Alloy additions are particularly effective in producing density and strength in heavy sections. The microstructural study of the alloys (page 81) was furnished by E. J. Edwards of the American Locomotive Co., Schenectady, N. Y. It will be observed that nickel permits the use of lower silicon in heavy castings, and produces strong, sound, commercially machinable iron with maximum resistance to wear.

Applications. High test gray iron in the range of tensile strength, 38,000 to 50,000 lb. per sq.in., is applicable to medium and heavy castings, particularly where the combination of strength and resistance to wear is essential. The table below gives some typical applications where this type of material has proven successful and economical. As remarked above, this type of material can be easily manufactured in any foundry providing the few necessary precautions and the manufacturing procedure outlined in this paper are followed.

APPLICATIONS OF HIGH TEST ALLOY CAST IRON

Casting	Per Cent Steel in Charge	Total Carbon	Silicon	Nickel	Chromium
Brake Drums	60	2.90 - 3.10	1.40	2.00	none
Cams	60	3.10	1.10	0.90	0.30
Cylinders					
air ammonia and CO_2	60 - 70	2.80 - 3.00	1.10	1.00 - 1.50	none
hydraulic compressor	50 - 60	-	1.00	1.00	none
printing press	50 - 60	-	1.00	1.00	none
steam	60	2.75 - 3.15	0.90 - 1.10	1.00 - 1.25	none
Dies					
clay sewer pipe	50	2.90 - 3.15	1.00 - 1.30	1.25 - 2.00	0.25 - 0.75
sheet drawing	50 - 60	2.90 - 3.10	1.00	2.50 - 3.00	0.75 - 1.00
sheet drawing	85	2.75	1.00	1.50	none
Diesel Engine					
liners and heads medium	60	2.90 - 3.10	1.00 - 1.20	1.50	none
liners and heads heavy	60	3.00	0.90 1.00	2.00	0.50
Frames - hammer	50	3.00	1.25	1.00	none
hammer	60	3.00 - 3.20	0.70 - 0.80	1.25	0.40
Gears - medium and heavy	50	-	0.80	2.00	0.60
medium and heavy	75	-	1.12	1.25	none
Locomotive					
cylinders	60	2.75 - 3.15	0.90 - 1.10	1.00 - 1.25	none
bushings, pistons and rings	60	2.75 - 3.15	1.40 - 1.60	1.00 - 1.25	none
Machine Tool Beds	50	3.00 - 3.15	1.00 - 1.25	1.00	none
machine tool beds	90 - 95	2.75 - 3.00	1.50 - 1.75	1.50 - 1.75	none
Plates - clutch	60	-	1.75	1.50	0.50
Plungers - hydraulic press	50 - 60	-	1.00	1.00	none
Pots					
alkali	80 - 95	2.70 - 2.90	1.25 - 1.50	2.00	none
lead refining	80 - 95	2.70 - 2.90	1.25 - 1.50	2.00	0.75
Pumps - medium and heavy	50	3.00 - 3.15	1.20	0.75 - 1.00	none
medium and heavy	80	2.75 - 3.00	2.00 - 2.25	1.50 - 2.00	none
Rolls					
paper	50	-	1.50 - 1.75	2.00	0.60
printing press	80	2.75 - 2.95	1.50	2.00	none
Sheaves	90	2.75	1.25	2.00	none
Tables - machine tool	60	3.00 - 3.15	1.35	0.75	none
Valve Bodies	50	3.05 - 3.15	0.90 - 1.00	1.50	none
valve bodies	60	3.00 - 3.15	1.25 - 1.50	0.75 - 2.50	none
valve bodies	70 - 80	2.75 - 3.00	1.25 - 2.25	1.50 - 2.00	none

STEEL

Personality . . .

By B. F. Shepherd
A Paper for the
Western Metal Congress

IN THE PRODUCTION of high quality parts of tool steel, the factors affecting the uniformity of the finished product must be controlled. Steel is purchased from various sources to a chemical specification often demanding unreasonably close limits and to meet certain physical standards of cleanness gaged by fracture or deep etching inspection. Design is criticized and altered to reduce the residual hardening stresses and to prevent undue concentration of service stresses. The latest hardening equipment, pyrometers and quenching sprays of special design are used.

Inasmuch as all of these factors have been regulated, uniform results are expected.

Unfortunately, uniform results do not always follow uniform heat treatment, for the steel has a definite *personality*. Personality is something which also characterizes human beings, cast in the same type of mold and probably having chemical composition within very narrow limits. The great confusion in existing data on steel is due to this difference in personality—a word which can be replaced to good advantage by the term "timbre." Steel may have a chemical composition well within the limits of a correct specification, and yet be entirely unsuited for a specific use. A common example of this is hardened tool steel containing an appreciable percentage of carbon in the form of graphite. The chemical analysis would show proper carbon, but not all of it is in the combined form.

The steel making fraternity, in times not long since past, called this difference in quality "body." "Body" in later years has been used to describe general quality characteristics and, very recently, the ability of tool steel to withstand repeated hardening without cracking (a test of rather doubtful value except for isolated service requirements). The term "timbre" has been defined in Technical Bulletin *C* of the Carpenter Steel Co. as the inherent "property of tool steel independent of analysis which influences the degree of hardness penetration and width of allowable quenching range."

It is the purpose of this paper to show (a) some hardening irregularities in tool steel, (b) the effect of timbre upon service life, (c) the necessity for the control of timbre, (d) the difference in timbre in the products of several manufacturers as shown by the hardenability test developed by the writer and published in *Transactions*, A.S.S.T., Vol. 17, January, 1930, (e) the degree of abnormality, and (f) that timbre exists not only in tool steel, but also in various alloy steels. In this work the entire metallurgical staff of the Ingersoll-Rand Co. has been cooperating; we also acknowledge help from F. R. Palmer, B. H. DeLong and G. V. Luerssen of Carpenter Steel Co., and S. C. Spalding of American Brass Co.

It is often assumed that a 100% hardness inspection is a guarantee that the accepted parts are satisfactory. As a matter of fact, hardness tests only indicate the hardness at the particular location tested, and are not a guarantee that a certain quality standard is being attained. Etching a hardened tool steel part may discover a large number of soft spots on the surface, indicating improper hardening. It is therefore necessary to check the *uniformity* of hardening by means of additional inspection of this character, if highest quality is to be maintained.

Small soft spots on the surface indicate a structural condition often much more serious than ordinarily supposed. Cross-sections taken through several parts having surface soft spots show that the total depth of hardening in several locations is greater than can be obtained by a normal hardening operation, and consequently indicates a hardening abnormality. This can be explained only by internal cooling stresses causing a pressure hysteresis which accelerates or retards the formation of martensite. Strains produced by such a structural condition are very much more severe than those produced in a normal hardening operation and render the part unsuitable for service.

No further argument is needed to emphasize the principle that great care must be exercised in the production of high quality work to insure that all parts have the desired structural condition in every region and on all the surface. What is often called "satisfactory quenching apparatus" is not capable of reproducing the required quenching conditions.

Two parts made from the same bar of steel and quenched from the same temperature are shown at the left and center of the view on this page. They were then cut in two with a thin emery wheel and etched to show the distribution of hardening. The part at the left was quenched in an open brine flush, in a manner that would ordinarily be considered improved hardening practice. Examination shows that the depth of hardening tapers off on one side to practically nothing, a condition which makes the part unsuitable for its intended use even though it does not show a single soft spot on the surface. The similar part in the center was quenched with what is known as a conforming fixture, whereby the brine was directed to all surfaces. A uniformly hardened product has resulted.

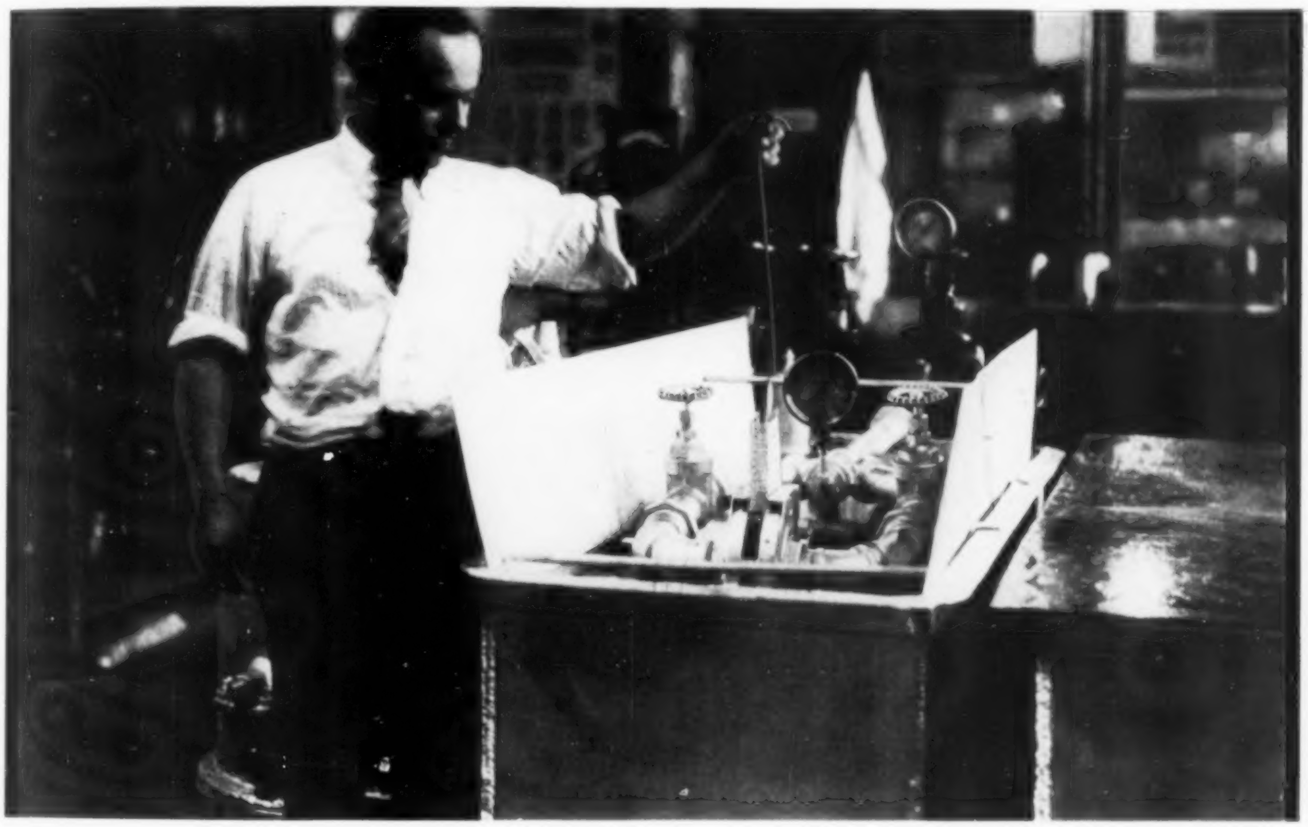
Timbre has been reported by other investigators as having an effect upon the service life. For instance, A. S. Jameson, in a paper entitled "Cold Heading Die Life" read before the 1930 A.S.S.T. Chicago Convention, showed the relation between case depth and die production. One of his steels which could be hardened ¼ in. or deeper gives 28,000 to 40,000 production per die end, whereas three others with shallower hardening characteristics gave production of 10,000 to 25,000.

We have found a marked effect of timbre upon the service life to parts made of 1-in. solid hexagon steel, properly hardened and in the same physical condition with respect to hardness. Chemical composition of the two heats of this steel is very similar (carbon 0.75%). One hardens uniformly 7/64 in. deep and has a working life of 3,468 min. The other hardens less regularly 5/64 in. deep and has a working life of only 2,043 min.

Uniformity of Hardening Depends Upon Quenching Methods and Timbre of Steel. Tools at left and center made of same bar, but center one quenched in conforming fixture. Tool at right shows performance of specialized hardening methods on steel of proper timbre.

Design also accentuates the necessity for the control of timbre. It is desirable on certain parts to have deep hardness in a certain location while the sections in other parts will not permit the maximum hardness to be obtained. As a compromise, the hardening is governed according to the old rule of "quench according to the thinnest section." At the right of the figure on the opposite page is shown a part which has been hardened, cut in two and steps. These discs are quenched in the special brine spray shown in the photograph (although still brine is also satisfactory) and broken to study the fracture, or cut in two and etched. For any temperature, the hardenability number is taken as the numerator of the fractional thickness in thirty-seconds of an inch of the thinnest section to have a core after this operation.

A comparison was made to determine the



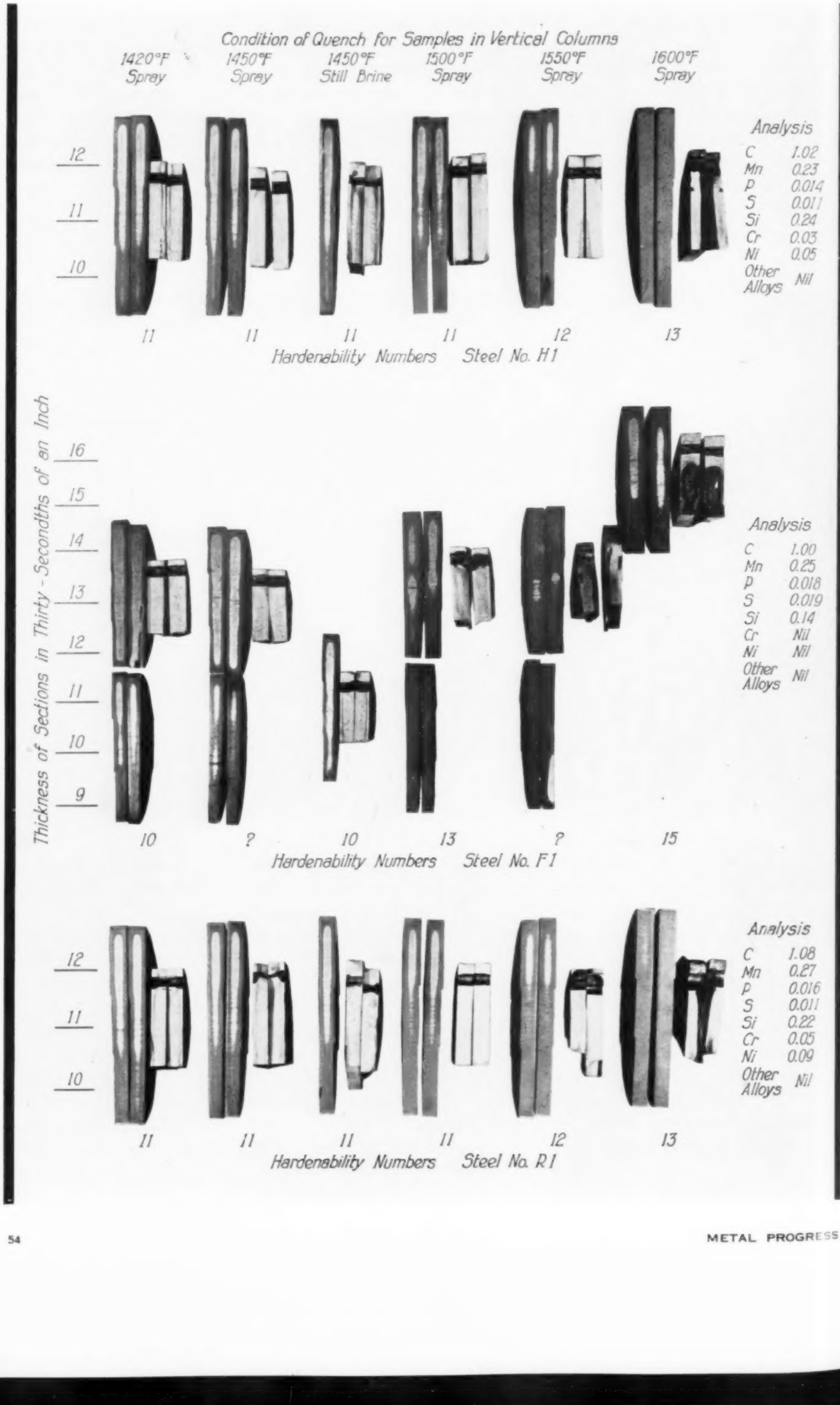
etched to show the distribution of hardness. The production of high quality parts of this character necessitates control of timbre to obtain maximum service life.

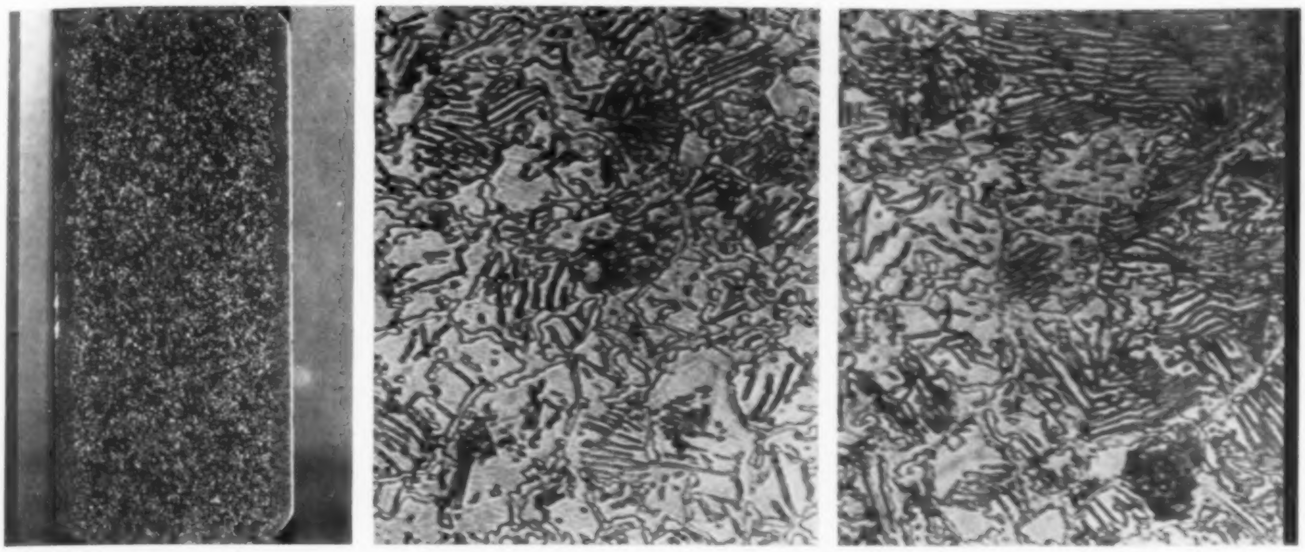
Steel, therefore, cannot be purchased indiscriminately with chemical composition and cleanness as a sole specification.

In the paper on hardenability above mentioned, the present writer described a test for the determination of this quality which has since been amplified. The test now includes the width of quenching range by varying the quenching temperature over a wider range. Briefly, the test consists of quenching discs of steel which have been step-ground in 1/32-in.

Quenching Disc to Check Hardenability Number.

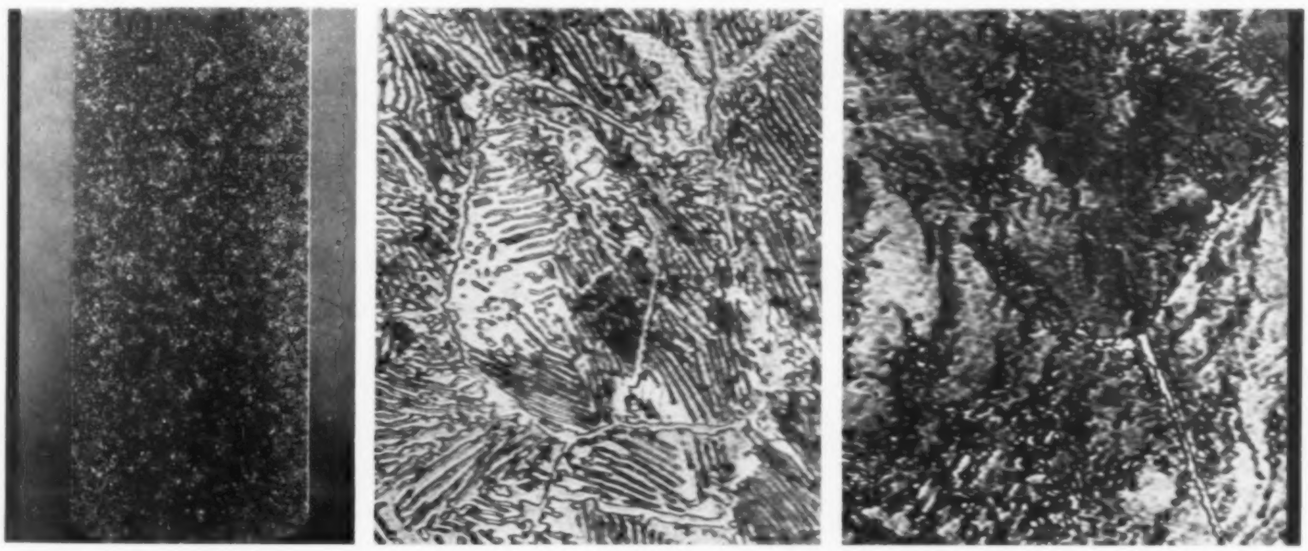
difference in timbre in the product of three different manufacturers—the steel being a 1.00 to 1.10 carbon tool steel. The results are shown on page 54 and are to a certain extent self-explanatory. It is important to note that the discs shown are duplicate discs, and not halves of the same disc; they show a very good check upon the hardening method and response of the steel to this operation. Previous experience with steels H1 and R1 indicated that the tests need only be made on the 10/32, 11/32 and 12/32-in. sections. On steel F1 it was necessary to use six ranges of thickness, as its timbre characteristics were unknown.


Condition of Quench for Samples in Vertical Columns
1420°F Spray
1450°F Spray
1450°F Still Brine
1500°F Spray
1550°F Spray
1600°F Spray
Thickness of Sections in Thirty-Secondths of an Inch
12
11
10
11 11 11 11 12 13
Hardenability Numbers Steel No. H1
Analysis
C 1.02
Mn 0.23
P 0.014
S 0.011
Si 0.24
Cr 0.03
Ni 0.05
Other Alloys Nil
16
15
14
13
12
11
10
9
10 ? 10 13 ? 15
Hardenability Numbers Steel No. F1
Analysis
C 1.00
Mn 0.25
P 0.018
S 0.019
Si 0.14
Cr Nil
Ni Nil
Other Alloys Nil
12
11
10
11 11 11 11 12 13
Hardenability Numbers Steel No. R1
Analysis
C 1.08
Mn 0.27
P 0.016
S 0.011
Si 0.22
Cr 0.05
Ni 0.09
Other Alloys Nil



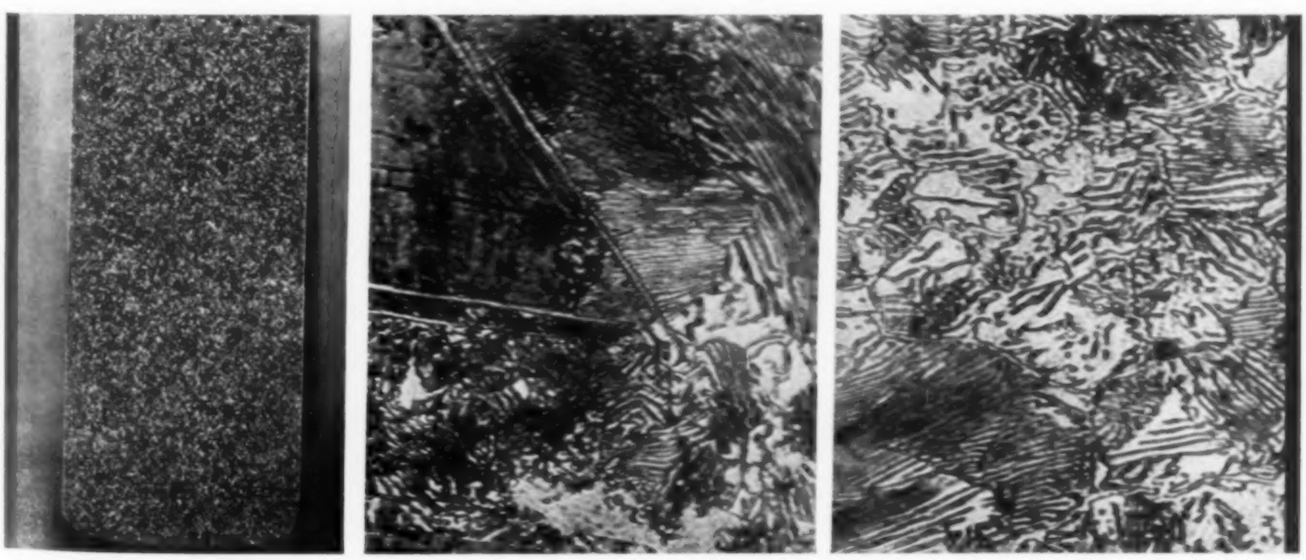
Disc, Enlarged 3 Times *Case—Magnified 750 times—Core*

Steel H1 Is Distinctly Abnormal



Disc, Enlarged 3 Times *Case—Magnified 750 times—Core*

Steel F1 Is Distinctly Normal



Disc, Enlarged 3 Times *Case—Magnified 750 times—Core*

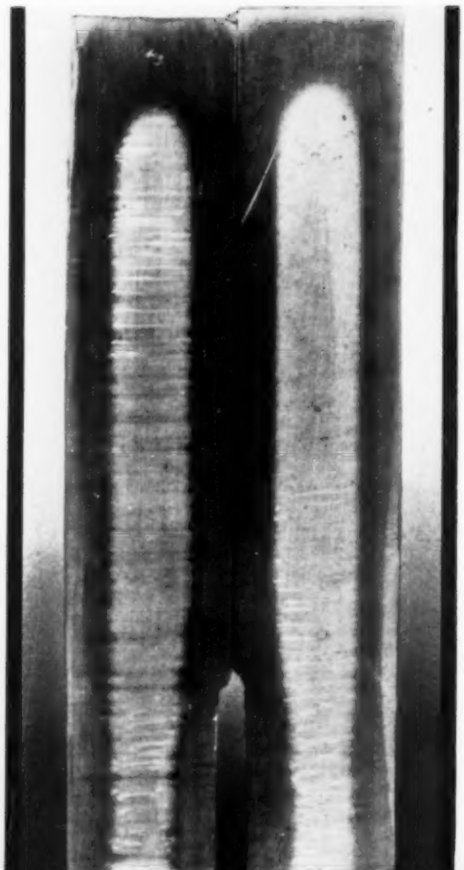
Steel R1 Is Intermediate in Normality

but on the 1,600°F. quench only one disc with three thicknesses was used.

It will be observed that the hardenability of steels R1 and H1 is not changed until 1,550°F. is reached. At this temperature the hardenability is increased from No. 11 to No. 12, and a further increase of 50° increases the hardenability to No. 13. Samples of each of these steels quenched from 1,550 and 1,600°F. show slight hardening cracks and a tendency to check in grinding, the latter temperature showing these to a greater extent. Fracture of each of these steels shows no appreciable coarsening from the higher temperatures, although the specimens are hardened through and have a "drier" appearance than the others.

Steel F1 has poor timbre. The hardenability changes rapidly with increase in hardening temperature. The fracture starts to coarsen badly at 1,500°F., and at 1,600°F. is quite crystalline. This steel cracked badly in hardening at 1,500°F. and over, and is especially prone to grinding cracks.

These characteristics are also reflected in the carburizing operation. To show this, discs of each of these three steels approximately ½ in. thick were carburized at 1,725°F.,



Above Steels R (left) and H (right) of Equivalent Hardenability Show Marked Difference in the Border Between Hardened Surface and Softer Core. 12/32-in. sections quenched from 1,450°F., about three times natural size.

Fractures From Bars From Two Heats of S.A.E. 3140 Steel, Indistinquishable Chemically. Top row of samples were taken from top of ingots at various stages of pouring heat A; second row taken from bottom of same ingots. Bottom two rows are corresponding samples from heat B. A has a fibrous fracture; B is crystalline.

and allowed to cool in the pot (8x8x6-in. size). A sector taken from each disc was examined metallographically along a longitudinal radial section. A marked difference in the response of these three steels to the carburizing operation is shown by macrographs on page 55.

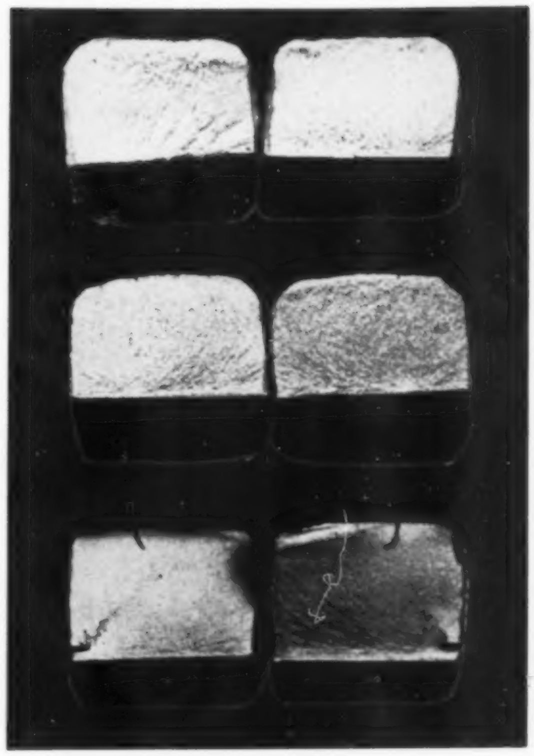
Metallographic examination at 1,000 diameters showed a still greater difference. Steel H1 is distinctly abnormal; the figures (reproduced at 750 diameters) show the case and core, respectively. The core of this piece was composed of both abnormal and distinctly lamellar pearlite grains.

Steel F1 (with poor timbre) is distinctly normal. Excess carbide in the case surounds the grains of distinct lamellar pearlite. The excess carbide in the core is also around the grain boundaries, the grains themselves being sorbitic pearlite. Small particles of carbide may be observed coming out of solution. All the grains in the core have this same type of structure.

Excess carbide in the case of steel R1 is principally in the form of intragranular needles, with small amounts at the grain boundaries. Some of the grains in the core are distinctly abnormal, some are distinctly lamellar pearlite, while others in other localities were found to be of irresolvable pearlite. This steel, therefore, cannot be classified as distinctly normal or abnormal.

The indications from this comparison (by means of the McQuaid-Ehn test) are that normal steel has poor timbre and that good timbre steels are not necessarily distinctly abnormal steels. However, I think it is the definite aim of manufacturers desiring good timbre to try to make an abnormal steel.

There are still other differences between steels of equal timbre characteristics. Extensive experience has shown that steel from manufacturer *H* would, after hardening and etching, show a more distinct border line between the case and the core than steel from manufacturer *R*. This difference is illustrated at the top of the page opposite, where the 12/32-in. sections of the hardenability test discs quenched from 1,450 F. are magnified about three times. The characteristic difference in border-line condition is very marked. At higher magnification (say 40 diameters) the difference is still more



Fineness of Fracture Is a Guide to Impact Strength of Heats of S.A.E. 3250 of Practically Identical Composition & Hardness.

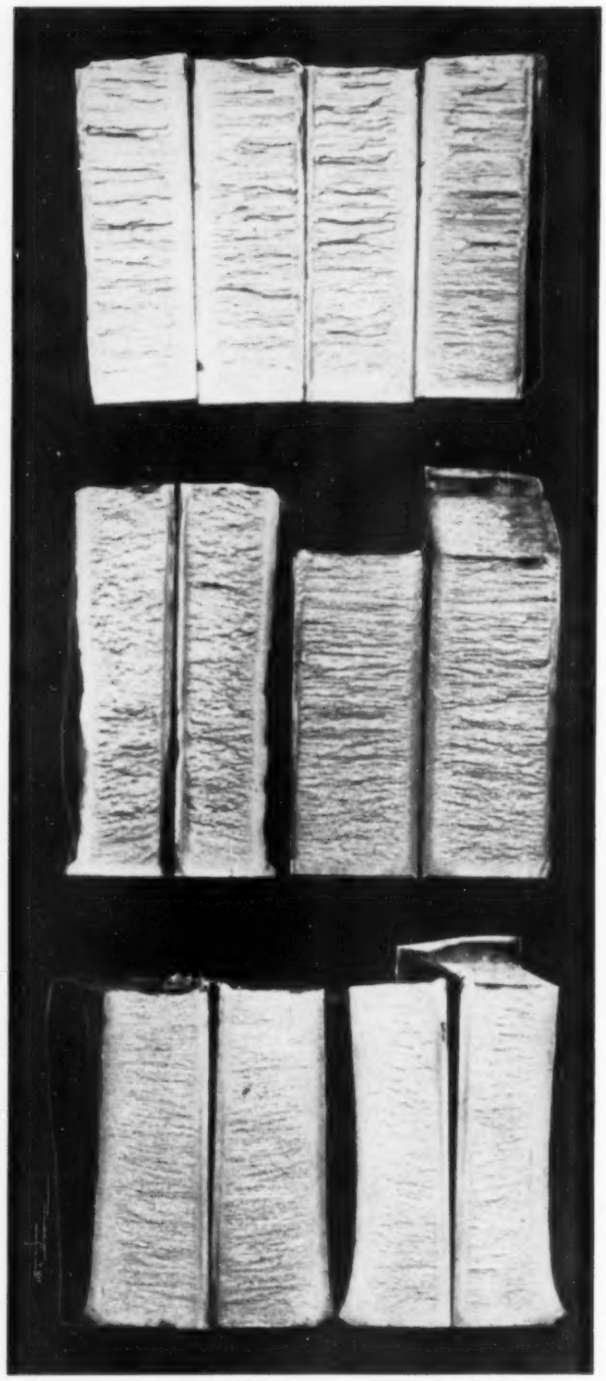
pronounced and is directly attributable to a difference in the critical cooling rate of the grains themselves. The difference between these two steels was previously shown to exist in the cores of the samples cooled slowly from the carburizing temperature; steel H1 had grains which were entirely lamellar or abnormal, and steel R1 had both sorbitic and lamellar pearlite grains. We attribute this condition to a difference in the critical cooling rate of the individual grains.

A larger dendritic structure in one steel (with corresponding, though very slight, structural heterogeneity) carries on into the finished bar, often resulting in a distinctly fibrous structure. The slight difference in chemical composition of such fibers results in a difference in critical cooling rate, which also accentuates the border-line condition under consideration.

The effect of this border-line characteristic upon service life is under investigation.

Timbre exists not only in tool steel, but in various alloy steels.

The lower figure on page 56 shows fractures of bars from both top and bottom of ingots taken throughout the pouring of two heats



Fibrous (Slightly Crystalline), Slightly Crystalline, and Crystalline Fractures of Three Carburized Chrome-Vanadium Steel Heats, Indistinguishable Chemically.

of almost identical composition. While these figures show only a difference in fracture, it is to be expected that this will also be associated with a difference in physical characteristics. The heat analyses of these bars were:

C	Mn	P	S	Si	Ni	Cr
0.40	0.55	0.026	0.029	0.12	1.49	0.72
0.40	0.62	0.026	0.026	0.16	1.50	0.67

All these bars are 2⅞-in. round, air cooled from 1,550°F., and annealed at 1,420°F. Fractures from one are fibrous, the other's are crystalline.

An illustration of the difference in response to a standard heat treatment of three heats of S.A.E. 3250 is shown on page 57. These pieces were oil treated from 1,500°F., annealed at 1,330°, then oil treated from 1,450°F. and drawn at 525. Chemical analysis is almost identical:

C	Mn	P	S	Si	Ni	Cr
0.50	0.50	0.019	0.011	0.28	1.66	1.18
0.48	0.43	0.02	0.012	0.14	1.65	1.07
0.50	0.45	0.017	0.014	0.18	1.58	1.13

The difference in timbre has changed the Guillery impact values about 100%, they being 2.5, 3.5, and 5.5 kg-m., respectively.

Furnace practice also has a marked effect upon the timbre obtained in chrome-vanadium carburizing steel, and this difference in timbre has a tremendous effect upon the service life of parts made from either type of steel. Fractures of representative discs of three heats of this material are shown on this page. These discs have been given the same heat treatment: Carburize at 1,625°F. for 10 hr. after reaching heat, cool in pot, reheat to 1,625°F., quench in oil, reheat to 1,475°F., quench in brine. The difference in core structure is quite obvious, yet the chemical analysis is quite similar, all heats conforming to this specification:

	C	Mn	P	S	Si	Cr	V	Ni
Min.	0.18	0.60	...	...	0.10	0.70	0.15	...
Max.	0.24	0.80	0.03	0.03	0.20	1.00	0.20	0.20

The difference in performance of heats of steel having the same type analysis has often been noted before. Failure of parts has frequently been unsolved after applying all available methods at our command. Many of these failures occurred even though the engineering factor of safety was very high and the material met the specification requirements.

That difference in quality of materials, which is not usually ascertained until trouble develops in fabrication or in the field, I call "steel personality" or "timbre." Development of tests to determine timbre in alloy steels is very much to be desired. The use of such a test on tool steel and the purchase of tool steel with timbre as one of the main criteria of selection (rather than the present emphasis upon narrow chemical limits) will result in an improved product.

Wider adoption of STRUCTURAL WELDING

. . . depends on comparative costs

By A. F. Davis
Abstract of Paper for
Western Metal Congress

A YEAR or so ago the board of directors of Irving Trust Co., New York, sent out engraved notes of apology to some 500 neighbors, asking their indulgence "during the unavoidably noisy weeks that lie just ahead" while the steel frame of their new building was being erected. Some time after this, the Union Trust Co. of Cleveland made an addition to the top of their building, but they sent no apologies for noise — they welded!

In order to picture the present status of structural arc welding, it seems desirable to give a brief history of what has transpired in its application to the erection of buildings, then to point out a few of the questions and what is being and has been done to solve them.

So far as the writer knows, the first structure in this country in which arc welding was used in an important part was the old plant of the Lincoln Electric Co. in 1916. A four-story concrete block building had its floors seriously overloaded and the blocks began to crumble. A complete welded steel skeleton was built into the existing structure without disturbing the factory operations.

About eight years later, the steel framework of a 12-story addition to the People's Outfitting Co. building was erected by conventional methods. Floor girders were welded into columns of the old structure — 103 of them — without disturbing the usual routine of the department store housed in the building.

In the fall of 1926 there was erected by Westinghouse Electric & Mfg. Co. at Sharon, Pa., the then largest all-welded steel frame building. This is a five-story warehouse requiring 790 tons of steel.

Another most interesting building was erected by the Austin Co. in Cleveland — a four-story building embodying several unique features, among which was the use of single-story columns and continuous beams welded in the middle of the building.

Notable buildings erected since this time include a factory building at the West Philadelphia works of General Electric Co., containing 1,000 tons of steel; an addition to the Homestead Hotel at Hot Springs, Va., fabricated and erected by American Bridge Co.; the power plant adjoining the Chalfonte Hotel at Atlantic City, N. J., fabricated and erected by Bethlehem Steel Co.; the 14-story, 1,400-ton office building of Edison Electric Illuminating Co. of Boston, Mass.; the 3,000-ton shop-riveted, field-welded building of Southern California Edison Co., Los Angeles; the 19-story building of Dallas Light &

Power Co., Dallas, Tex., erected by Mosher Steel Co., and a building for Dallas Gas Co., designed for 22 stories (of which 14 stories are being erected at present) fabricated and erected by Austin Brothers.

Recent statistics collected by the American Welding Society show that welding has taken a prominent part in over 100 buildings or structures, with an estimated tonnage of over 100,000. Adverse building codes have been one of the factors that have retarded the more rapid progress of structural welding, but more and more cities are adopting, either wholly or in part, the welding code suggested by the Welding Society.

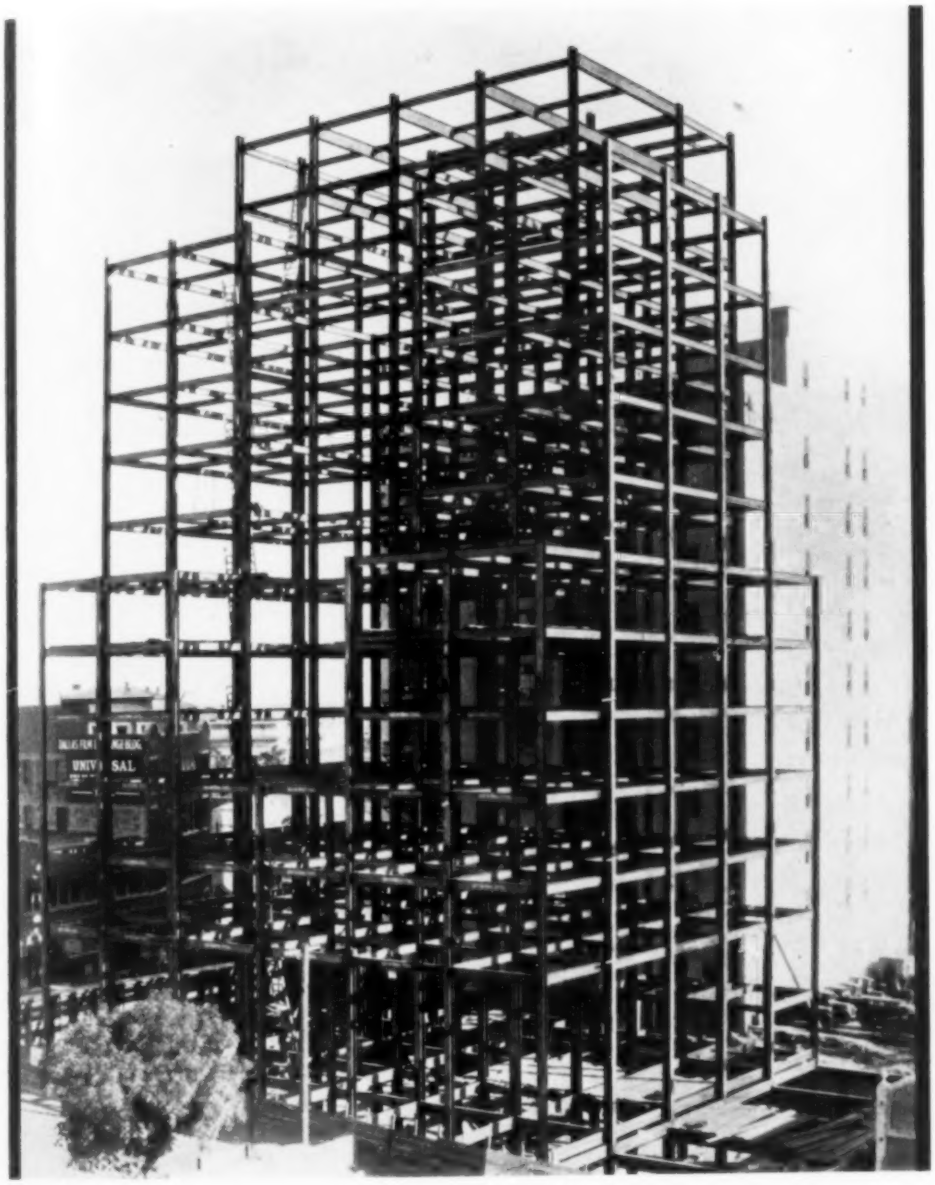
The reliability of welding is often questioned, particularly by those who are not familiar with the process. In this connection, it is interesting to cite some very severe tests on packing houses erected in Florida with steel arched roofs, the arches being constructed entirely by arc welding. A partially finished building of this type was struck by a hurricane, blowing a masonry rear wall over on some bar joists which had been welded to the supporting beams by short fillet welds. All welds held, causing even the beams and the supporting columns to become badly distorted.

Another question frequently heard is about the uniformity of welds. It is safe to say that, with proper procedure control and inspection, a uniformity equal to that of any other mechanical type of joint will be secured. This statement is being amply confirmed by an extensive program of tests being made by a committee of the American Welding Society.

Multiple specimens of several types and sizes were prepared by 36 representative fabricating shops throughout the United States and Canada. Operations were governed by uniform procedure and inspection regulations. The large number of tests so far completed indicates a uniformity verifying the previous statement in this respect.

Mention has been made of proper procedure and inspection. By proper procedure is meant proper size, length and sequence of beads, proper electrodes, proper currents for the work, proper equipment and proper prelim-

Welder Making a Joint in the Frame of an Addition to Cleveland Union Trust Building. No apologies for noisy racket were needed.



All-Welded Steel Skeleton of Dallas Gas Building, 14 Stories Erected, With Provision for an 8-Story Addition.

Elimination of noise, and possible economies. Recently, public notice has been largely focused on *silence* as an advantage of structural welding; but it is the writer's belief that welding in structural work is going to depend on whether savings in dollars and cents can be made. It is a remarkable fact that so far there has been no saving, or at least very little, where structures have been entirely or largely fabricated and erected by welding.

Unquestionably, there is a saving in the amount of steel. It is estimated on good authority that this may be as much as 15 to 20%.

These savings in steel have been largely wasted by delays in erection, unnecessary welding due to extreme conservatism or caution of the designer, and to avoidable overhead or inaccessible welding.

Difficulties or increased cost in erection came from the trouble in holding or clamping members in place until they can be welded, and in plumbing or squaring the building. These difficulties can, of course, be overcome by using bolt holes for erection purposes. This scheme has numerous advantages and some disadvantages. It permits the work to proceed as in riveted construction with which every erector or fabricator is familiar. Naturally, any work with which one is familiar proceeds more rapidly than work with which one is unfamiliar. Its disadvantage lies in the fact that the steel must be put through a fabricating shop, entail-

inary tests of each operator to determine his fitness and ability. Such tests have already been standardized by the American Welding Society.

We have referred also to proper inspection. Methods have been devised for testing welds which are non-destructive, but none of these is practical for field work. Visual inspection remains, and it is the one most used. To the uninitiated, all welds may look alike, but to one experienced in arc welding, the appearance of the finished bead will indicate to a remarkable degree the dependability and strength of the weld.

The question, however, which is probably heard most is: Why weld structures at all? There are, as the writer sees it, two answers:

Part of a Shipment of 200 Roof Trusses for Mill Building. All joints made by welding with "shielded arc" in a structural fabrication shop.

ing an additional operation, and it is almost as cheap to punch several holes for rivets as it is to punch one hole for a bolt. It is the ideal of welded construction to by-pass the structural shop entirely.

A procedure was recently suggested by J. F. Lincoln, whereby angles and lugs, which had been punched and prepared in the fabricating shop, are welded to adjoining structural members, thus "welding on a hole."

Even without this expedient, many economies are now possible through welding and which do not interfere with erection by the usual methods.

One of these, well known to structural engineers, is in the design of wind bracing for tier buildings. Inefficient details, requiring rivets to work in shear at low efficiency, may be replaced by simple knee braces welded into the frame. The welders follow the riveters without interfering with them, and without getting in the way of the cement work or masons.

This emphasizes an important point — that the fabricating shop may make real economies by welding, unhindered by the external influences of field erection.

As an example of the economies of welding in the shop work, it may be mentioned that the Austin Co., with headquarters at Cleveland, has just fabricated in this manner 136 roof trusses 70 ft. long and 9 ft. deep in the center, and 63 others 40 ft. long and 8 ft. deep, for the new factory building of the Simonds Saw & Steel Co., Fitchburg, Mass. (This new plant is also notable for being the first industrial plant designed without windows and to operate under "controlled atmospheric conditions.")

Harry E. Stitt, chief engineer of the Austin Co., speaking of these welded trusses, said, "They are stronger, stiffer and better trusses, also 15 to 20% lighter than similar trusses of riveted construction would have been. They were constructed at a cost comparable to equivalent riveted-type trusses."

It is safe to say that this phase of structural welding will increase more rapidly than welding in field erection.

Even a Hurricane Cannot Tear a Welded Joint Apart.

Western Congress TYPIFIES EXPANSION ...ON THE WEST COAST

By W. H. Eisenman

IT IS A SHORT SPAN of time from 1923 to 1931, yet it has witnessed the formation on the Pacific coast of two outstanding chapters of the American Society for Steel Treating and their development to the point where they are again sponsoring a Western Metal Congress and a Western Metal and Machinery Exposition, this time in San Francisco.

From a historical point of view, it is interesting to recall that Los Angeles Chapter was organized March 14, 1923, with 23 charter members, a group collected largely by the efforts of C. P. Miller. Robert B. Dunsmore was the first chairman. San Francisco was not long in following suit. Golden Gate Chapter was formed in the spring of 1924, from a nucleus of 18 members of the national society residing in the bay cities. At a meeting held April 12, 1924, a petition for a charter was signed by 102 men, setting at that time a record for membership at the time of organization.

From the very beginning a spirit of enthusiasm and the will to accomplish worth-while undertakings has pervaded the officers and members of both the Golden Gate and the Los Angeles chapters. Beginning with a modest membership, the Coast chapters have grown with the increase of industrial activities in that section until now they total approximately 500.

Consequently, their activities have been far reaching. Recognizing the need for a better appreciation of metallurgy, both chapters have been conducting outstanding educational courses for the benefit of the industrial communities they serve. In the second year of its existence, the Golden Gate Chapter sponsored a highly successful 15-weeks' course in practical metallurgy for steel treaters at the Oakland Vocational School. Some of the members of this class came from plants located 40 miles away. Repetition of this class from year to year indicated the need of a specialized text book, and such a one was prepared and printed, extending about 130 pages in length. A similar noteworthy course was established last year in Los Angeles. (Details are given on page 100 of this issue.)

Having organized efficiently for the metallurgical fraternity in these two centers, the next effort was to expand the influence to others "along the fringe."

At that time it was the opinion of the board of directors of the national society, as well as of the Pacific Coast members, that the annual National Metal Congress and Expositions were not serving the needs of the far western industry interested in the subject of metals. Consequently, the first Western Metal Congress and Exposition was held in Los Angeles in 1929, after the matter had been under consideration

Dutch Mill
Golden Gate Park

San Francisco
Sky Line
from Twin Peaks

Redwood Highway

Water Falls of Great Beauty in Majestic Mountains are Harnessed in Lower Reaches of the Rivers

Nature's Ramparts

Auditorium at Night

*San Francisco,
From the Bay*

*Oriental Garden
Golden Gate Park*

Montgomery Street

Photos by H. S. Lawton, W. W. Swadley and Morton & Co.

by the board of directors for about two years. That effort was a cooperative movement by all the national technical societies with groups on the Coast. It was conceived, inaugurated, and carried to a successful conclusion.

A program was arranged in which the various sessions were sponsored by different cooperating societies, each society being responsible for the papers to be presented at its particular session. There were five days upon which outstanding technical contributions were presented and favorably received by the hundreds in attendance at the congress.

Recognizing the fact that attendance at the Western Congress and Exposition included representatives from all of the eleven Western and Rocky Mountain states, the national board decided that a two-year interval should be maintained between western expositions. In accordance with this plan, the second Congress and Exposition will begin on February 16 and continue to the 20th in the Civic Auditorium, San Francisco.

The same method of procedure and organization has been perfected for this congress as with the first. The following thirteen societies are cooperating and sponsoring the combined event:

- American Chemical Society
- American Institute of Electrical Engineers
- American Institute of Mining and Metallurgical Engineers
- American Society of Mechanical Engineers
- American Society for Steel Treating
- American Society for Testing Materials
- American Welding Society
- Institute of Metals
- National Purchasing Agents Association
- National Association of Power Engineers
- Pacific Coast Electrical Association
- Pacific Coast Gas Association
- Society of Automotive Engineers

A technical program of outstanding merit and covering in its broad application the entire metal and manufacturing industry has been prepared under the direction of Howard S. Taylor of the mechanical engineering department, Stanford University, who has had the cooperation of one representative from each of the participating societies on a program committee. No less than 14 contributions to this series of meetings have been secured from members of the A. S. S. T. after solicitation by their society representative, many of which are given in abstract in this issue of METAL PROGRESS.

The exposition has attained remarkable success in this year of industrial depression. Over 125 exhibitors are participating with displays which cover such a wide field of application that every representative manufacturing industry in the West, whether it be mining, lumbering, oil, shipping, machinery, or any other in which metal plays a part, will find much to arouse its attention and interest.

It is probably not as well known as it ought to be that manufacturing on the West Coast has greatly expanded in the last few years. It would be difficult to think of any common commodity that is not produced on the Pacific Coast and for which the raw materials are not available in the same territory.

Manufacturing for local needs necessarily keeps pace with the growth of population, and the last census has shown a record-breaking increase in population of the western section of the United States, and of California in particular. The value of the combined manufactured products of California's two largest cities totals to a figure exceeded by only two cities in the United States, a fact which will be illuminating to many people who look upon California as nothing more than a tourist paradise.

While it is true that great production lines are absent (except in a few commodities such as tires, electric motors and tractors), yet a multitude of smaller manufacturing plants are running up this impressive total. A most important reason for the success of a new manufacturing firm in the West is that the organization is almost invariably headed by an engineer with youth, energy and ambition. An abundance of skilled and semi-skilled labor, an original investment for a manufacturing building very much less than where weather conditions are rigorous, and low water freight rates to the eastern seaboard and the Orient — all these are important factors in the progress and success of the western manufacturer.

Truly the West is an empire in itself!

EDITORIAL

'Change; San Francisco

A CASUAL GLANCE at the front cover, decorations and pictorial "spreads" of this issue of METAL PROGRESS will create a Californian atmosphere appropriate to the Western Metal Congress, being held in San Francisco, Feb. 16 to 20. A reader will immediately find that the technical articles (with one important exception) are derived from A.S.S.T. papers for that gathering.

They are a notable group. Members of the society have responded so generously to requests from the program committee that two excellent contributions were crowded out of this issue for lack of space.

Technical Papers for the Western Metal Congress

Even though none of the articles contains the complete text and illustrations of the paper as it will be presented in San Francisco, it is hoped that each extract or abstract gives the high lights or the complete argument. Those who are interested in examining an individual subject in greater detail are invited to write to the national office of the society for a copy of the entire paper in pamphlet form. Manuscripts will be so prepared as soon as necessary approval is secured from the Publication Committee, and will also be included later in the next bound volume of *Transactions*.

It is the hope of the officers of the American Society for Steel Treating that this method of prompt issuance of technical material will appeal to the members as an improvement over the more deliberate methods of publication previously in vogue.

THOSE OF US who were riding bicycles 30 years ago can remember that the nickel-plated handlebars started to rust in a few weeks, and the wire spokes lost their bright shine even sooner. A good job of silver plating was also rare enough for Rogers Brothers to make an enviable reputation for table ware which would endure for years. In fact, the average performance of the plating room was so mediocre that "plated" metal ordinarily meant shoddy goods.

This situation gradually improved with passing years. Foremen platers have organized themselves into a society, and the resulting interchange of opinions enabled the second or third raters to bring their practices more in line with the best of the current art. But the process continued to be largely rule-of-thumb. Only in comparatively recent years has there been much commercial research into the whole problem of surface finishes, to the great advantage of the art both in the quality and

How Good Can an Electroplate Be Made?

the variety of work performed satisfactorily.

These advances have not reached the limit, by any means. Rust-resisting coatings of zinc, cadmium and chromium have been added to the resources of the finishing department, yet much remains to be learned about their properties and the possibilities of improvement by minor changes in operating conditions. One is inclined to venture the remark that we don't yet know how *good* we can make a copper, a nickel or a silver plate. What are the possibilities of making an adherent and non-porous coating of any of these metals, that is to say, a superficial layer entirely free of pinholes or of intracrystalline cracks?

An answer to this question would be worth having. Probably a really fine job would increase the cost but a minor percentage, since the bulk of the expense is in labor-consuming operations common to any plating job, such as cleaning, handling, buffing and polishing. It is also possible that articles with a superior finish could compete successfully with other articles made of some of the stainless alloys now being marketed.

As an instance one can reasonably doubt that the question of chromium plate vs. stainless metal for automobile trim has yet been answered with finality, because so far there have been too many limitations imposed by the purchasers. Purchasing agents have not yet discovered that a satisfactory chromium plated job cannot now be done for the same price as a nickel plated job. Possibly the more costly reagents and more precise control will always maintain a price differential. On the other hand, a really stainless and ductile iron is an expensive alloy, and perhaps metal manufacturers may never be able to make it so it is not only stainless but cheap, and easy to work and easy to polish as well.

Of course, a sheet of good 18-8 is immeasurably better than a poor sample of chromium plate. But it does not follow that it will be impossible to make a durable and satisfactory plated job, nor that all the "stainless" metal going into automoble trim will not spot or rust. Only when both materials are in the same condition after, say, five years' service, can the relative value of the two alternative substances be computed.

Rapid Advance In High Frequency Induction Melting

IT IS MORE than a coincidence that recent issues of METAL PROGRESS have carried three articles about high-frequency induction furnaces. When editorial material about a certain device comes spontaneously from steel makers in Pittsburgh and Germany and from bronze foundrymen in New England, it is certain evidence that widespread interest exists.

The fundamental idea of this type of furnace was conceived by Prof. E. F. Northrup of Princeton University during 1916. Dr. Northrup determined mathematically that small furnaces (sizes such as might be sold for experimental work) would require very high frequencies, on the order of thousands per second. In those pre-radio times the electrical equipment was costly and fragile in the highest degree. Nevertheless, the furnace had very attractive possibilities — an ability to melt without contamination from furnace atmospheres or electrodes, without superheating the metal container, and without building a transformer into the very furnace. These advantages were so substantial that G. H. Clamer (the guiding spirit of Ajax Metal Co. and Ajax Electrothermic Corp.) determined to sink some money into commercial development, and the furnace made its debut in the fall of 1917.

Several sets were sold to research laboratories and a few were put to work melting rare or semi-precious metals. But for a long time headway was slow. The electrical equipment was unsatisfactory, the refractories were inadequate, and the first cost was excessive. The recent revival in interest in the furnace indicates that these three major problems have been solved, and that the faith (and it is hoped the

pocket-book) of the inventor and his financial backers has been rewarded.

First, the electrical equipment: It was shown theoretically, and verified experimentally, that such high frequencies as were used in the small laboratory furnaces were neither necessary nor desirable in units melting 500-lb. heats or bigger — frequencies of about 1,000 cycles per second are all that are needed. General Electric Co. produced a motor-generator set capable of giving these frequencies in 1925, and by 1926 their commercial application was verified in a battery of furnaces melting "german silver." With these rotary converters, and with condensers mounted in oil-cooled tanks, as rugged as a modern transformer, it may be said that the electrical problems and the excessive cost have simultaneously been removed.

Refractories have been under continuous study. The most satisfactory so far developed is a tamped-in lining of dry granular materials, of high purity and without binder, burned or sintered at the interior solely by heat in the melted charge. The nature of this material varies, of course, with the nature of the metal melted. Pure zircon (75% granules and 25% pulverized) seems to be almost ideal for most purposes — it has a low coefficient of expansion, a high softening temperature, and is neutral in chemical reaction.

A record of recent and notable installations may prove the point that these three principal handicaps existing 12 years ago have been successfully removed. The American Brass Co., with fifteen 650-lb. furnaces melting german silver since 1925 (a total of 1,500 kw. electrical load), has recently doubled the capacity. Pioneer melting for alloy steel castings was done, commercially, by Duriron Co., Dayton, Ohio. Babcock & Wilcox Tube Co. at Beaver Falls came next, with a furnace for alloy and carbon steel castings, closely followed by Lebanon Steel Foundry, Lebanon, Pa. Pioneer work on special steels for forging and rolling has been done in a furnace of moderate size at Midvale steel works, Philadelphia.

Carpenter Steel Co., Heppenstall Co., Firth-Sterling Steel Co. have noteworthy installations on special steels — primarily tool steels — one of the furnaces in the last-mentioned plant having a capacity of one ton. Another one-ton furnace is making experimental melts of superheated cast iron at United States Pipe & Foundry Co., Burlington, N. J. Watertown Arsenal has one 1-ton and one 2¼-ton furnace melting alloy steels for casting gun tubes by centrifugal methods, while the Illinois Steel Co. has issued specifications for a 3½-ton furnace for its South Chicago plant. The latter will be powered with a high-frequency generator delivering 1,125 kw. and will melt approximately 48 tons in 24 hr.

Without listing any of the notable installations abroad, it may be estimated that the grand total, including laboratory furnaces, is approximately 25,000 kw. When proponents of a device, which a dozen years ago was a delicate piece of laboratory equipment, plausibly speak of competing on a dollars and cents basis with open-hearth furnaces for the production of quality steel, it may be certain that we are again viewing one of those meteoric advances which occur so frequently in this blasé age.

THAT THE EARTH is a machine, a complex structure built of several parts, in slow motion one relative to another, is the novel and stimulating conception of the eminent British geologist, Prof. J. W. Gregory, discussed in a recent lecture before the Institution of Mechanical Engineers. It is the interactions of the different parts of the machinery which control man's destiny, which drain the surface and render it habitable, which supply us with fresh water, maintain a chemical balance in the atmosphere that we breathe, and raise from the interior not only the plant food but the metallic materials of construction.

The whole body, however, he likened to a huge spherical projectile, "traveling at an enormous velocity through space. It consists mainly of an iron shell which, like some of those of modern artillery, is hardened with an alloy of nickel."

Uses of . . .

STEEL CASTINGS

as affected by Welding

IT IS PROBABLE that many engineers have been interested in several articles on the relation of welding to the production and use of steel castings, which have appeared recently in technical journals. Some clarifying and some confusing statements have been noted in these articles. Perhaps the present writer can throw some light on the subject. The task seems worth trying. And we might appropriately start our present discussion by specific mention of one of the articles to which the writer takes exception in no conscious spirit of industrial prejudice, nor in a spirit of unfriendliness toward another writer who has, I think, incomplete data.

This author, in an editorial in METAL PROGRESS, October, 1930, spoke of the substitution of two welded jobs for steel castings, in both of which instances the changed construction was said to have been caused by difficulty in getting castings free from objectionable defects. He then expressed himself thus: "Since steel castings have been exploited preeminently as a quality product, such incidents as these are worthy of careful consideration by the industry. Forgings have definitely secured the upper hand in high pressure pipe fittings, valve bodies, and such like because they are not so liable to develop a leak under test and cause expensive and extensive replacement. Are castings destined for further discrimination by purchasers who are not interested in high pressure work but who expect to get sound metal, sound underneath the skin, when they are sold a 'quality' product?"

By R. A. Bull

Obviously I cannot now take issue with one detail of the article because I know nothing about the particular substitutions spoken of as being desirable, due to defective steel castings. But there is justification for discussing some of the comments. The result may be useful to some engineers who otherwise might form an incorrect impression of prevailing conditions.

If steel forgings had, as claimed, definitely secured the upper hand in high pressure pipe fittings and valve bodies, there is quite a number of very successful concerns regularly producing large tonnages of castings of the kinds mentioned which would be much more nervous than they appear to be about the future of their businesses. It is not necessary to enumerate any of the outstanding firms whose products so largely consist of steel valve castings and cast steel fittings for pipe lines for the power and oil industries.

In my opinion, there are several very good reasons why there does not seem to be in prospect, much less in existence, any diminished utilization, so far as relative tonnages are concerned, of cast steel material for such purposes. One interesting reason among these is apparently occasioned by the peculiar nature of the material. It has been the experience of a number of large consumers who have no apparent reason to be influenced by prejudice, that steel

castings are decidedly superior to steel forgings where there is erosion created by high velocities of fluids in pipe lines. Seemingly the granular structure of a steel casting, possibly *because* it does *not* get the degree of refinement producible by hot working, enables the product of the foundry to offer more resistance to such erosive action than does a steel forging of fairly comparable chemical composition.

Endurance under service conditions is the safest, therefore the most reliable, criterion by which to judge the relative merits of materials. Unquestionably cast steel fittings under high pressure conditions (at normal as well as at high temperatures) have fully justified the confidence of engineers who have installed them. We know of no more instances of failure of castings than of forgings in such applications. Under the conditions incidental to such installations, final cost is a very important factor. The number of pieces required is a vital element to be considered when comparing the initial expense of using forgings with that of employing castings. No power plant or oil refinery engineer who is competent and honest, as well as thoughtful of his future reputation, would install steel castings under high temperature or high pressure conditions, even at a considerably lower original expense than would be incurred by the use of forgings, if he did not firmly believe the selected material would be satisfactory in the long run. It is therefore significant that the largest companies that have previously used such products continue to buy steel castings for such purposes. At this time, when the steel casting business, like others, leaves much to be desired from the standpoint of orders being booked, those who make their living by steel casting production draw comfort from the positive knowledge that forgings have not "definitely secured the upper hand" in these fields.

In the previously quoted paragraph the last sentence asks a question that seems to call for an answer. The query *per se* is not one to which reasonably minded steel founders can object, except for the use of the word "further" in connection with discrimination by purchasers, indirectly suggested; and except for the use of quotation marks in mentioning the sale of steel castings as a "quality product," thereby impliedly questioning the satisfactory behavior of material made in the steel foundry. We have no disposition to quibble, and shall waste no time to indicate a supersensitiveness greatly disturbed.

It is more appropriate for consumers than for writers in a neutral or detached position to speak in positive terms based on experience, in any general discussion as to the probability or propriety of discrimination exercised by users to the disadvantage of steel castings on the

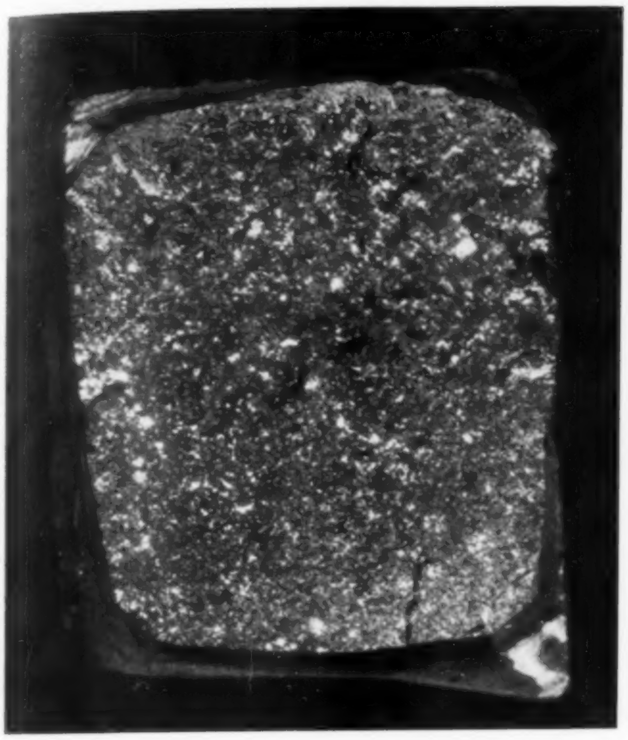
These Gages Are Used Daily. Dimensional accuracy is required nowadays for many steel castings. The gages shown here are part of the equipment of the chief inspector of a progressive steel foundry.

grounds that there is insufficient likelihood, ordinarily, of getting sound metal underneath the skin. Here again we feel impelled to repeat in substance what we said previously, *viz.*, that behavior under conditions of service is the most satisfactory answer to any such question. Performance and ultimate cost are the two factors that have influenced engineers not only to continue using steel castings in most of the applications where they have been heretofore employed, but to install them in new applications continuously being developed, new applications where very severe conditions demand soundness to a degree that is not exceeded by the stresses borne by any metal part, whatever the material used for it.

We do not seem to disguise the fact that welded structures have economically taken the place of castings for some purposes, but the cases are rare where such substitution has been made to the ultimate disadvantage of the steel foundry. Naturally, the iron foundry has suffered more from this sort of thing than the steel foundry. As pointed out in a recent illuminating article which appeared in the November issue of Metal Progress, written by Messrs. Namack and Hobart, some of these substitutions have been favorable to the extended use of small and medium-sized steel castings. Portions of some assemblages separately made in the steel foundry have been economically joined by welding to provide the most economical structure for the purpose intended.

It is my opinion that foundrymen will never be able fully to counteract the bad handicaps of design presented by some kinds of castings, such as the typical valve casting where a very heavy section is joined to one that is relatively very thin. But it is pertinent to point out that one does not get either in castings or forgings the same physical properties in a test specimen cut from a $\frac{3}{4}$-in. section which one obtains from a 5- or 6-in. section in the same part, if each test piece is taken from the heart of the member. This condition, based on natural laws, is not appreciated sufficiently to influence designing to the fullest practical extent for any kind of industrial metal product. The more simple the design, and the more nearly uniform the sections of the piece, the better is the job, whether a casting, a forging, or a welded structure.

What has just been said may be considered more or less as extraneous to the discussion of a topic like welding. But it has its place because producers of metal parts, in our opinion, will render a distinct service to those who use such material if they emphasize more strongly than in the past those relatively simple

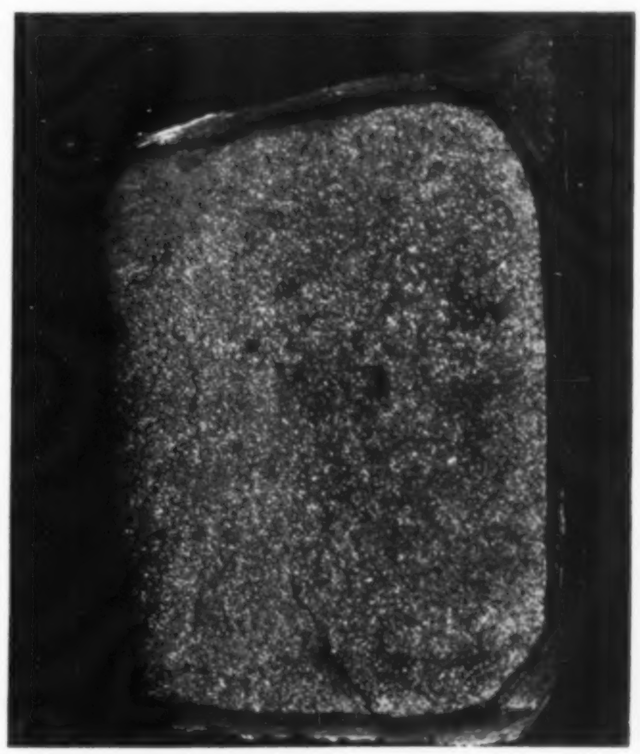


factors of design which influence behavior very greatly, due to the changes that take place as the result of temperature, largely according to the period of time during which metal is subjected to structurally or chemically modifying heat in any one of several manufacturing processes. Obviously, application of heat must be considered when we try to determine the influence of the weld on the joint made by the arc or by the oxy-acetylene blowpipe.

In that connection, it is worth while to refer to the statements made in an editorial in METAL PROGRESS, November, 1930, that since "skelp and plate do not represent the maximum of excellence, it is easily possible that the act of welding may actually leave the region at the junction in better physical condition than the body of the original steel. Such a transformation can be effected by a shrewd combination of heat, pressure and quenching (such as easily arranged in resistance welding machines) with scarcely any change in the chemical composition of the metal at the joint. If the full possibilities of alloying and heat treatment are utilized in fusion welding by oxy-acetylene flame or electric arc, then again we see no reason why the metal at and alongside the joint may not be of higher physical properties than the best boiler plate, as it comes from the mill." In view of the fact that there has been, probably with good reason, such an extended use of welded plate material for making pipe lines, it is questionable if any plate mill would attempt to controvert that last statement. There are, however, a number of important considerations that appear to have been overlooked by the author of the comments above quoted.

When what he wrote is read carefully, it is apparent that he did not mean to argue that the temperature influence of the gas torch or the arc used for welding may *alone* be expected to result favorably on the condition of the metal in or adjacent to the weld. A hasty or casual reading might lead to an incorrect interpretation of the meaning. It is partly for that reason that we would like to make some comments of our own.

Obviously, there is no way of controlling the temperature produced during the welding operation, in so far as that temperature affects an area close to the weld. It is trite but worth while to say here that heat treatment must be controlled within a fairly close temperature range to produce the result desired, and that



The Same Casting, Before and After. The coarse appearance of the one fracture is explained by the fact that the casting was in no way heat treated. Suitable normalizing greatly decreased the grain size.

one may obtain a wide variety of physical properties, depending upon the degree of heat applied, upon the time of the heat application, upon the method of cooling employed, and upon one other factor to which we shall refer later. No one could reasonably maintain that the heat generated by the welding operation, in affecting an adjoining portion of a piece of steel, probably leaves that adjacent region in better physical condition than it was originally, without appropriate supplementary treatment. In this connection it is interesting to note the growing commercial practice of annealing important welded parts. Obviously, this improving operation cannot be performed following the welded fabrication of bridges, buildings, and other important structures — a circumstance that justifies serious consideration by those who, in following metallurgical developments, find convincing evidence of the desirability, whenever possible, of giving a heat refinement for the relief of strains in metal that has solidified quickly in the making of a weld.

In the paragraph last quoted, there is a qualification to be emphasized in connection with the statement that there is "scarcely any change in the chemical composition of the metal at the joint." The extent to

which significant changes in chemical composition may be expected is dependent, of course, upon the elements in the steel, upon the degree to which these are oxidizable at the welding temperature, and upon the precautions taken in excluding or limiting the presence of oxygen; in other words, the extent to which the molten metal formed during welding can be protected from the shop atmosphere. Anyone who has made or examined many analyses of ordinary grades of steel that have been welded, and who has compared the chemical determinations with those from analyses of the "filled-in" metal forming the joints, knows

Grinding Down the Stubs. Sparks shower as the swing grinder smooths the spot where the gate is knocked from the casting.

the vast differences generally found in the chemical compositions, decidedly influencing physical behavior, when no opportunity has been afforded for preventing or restricting oxidation by the presence of hydrogen or some other blanketing medium.

Now it is important to keep in mind, when generalizing on the opportunities for maintaining or improving the physical and chemical characteristics resulting from welding, that nothing which limits or prevents oxidation is customarily employed in ordinary commercial fabrications. It is the every-day product of the welding operation that most readers of articles like the one just quoted and like the one which prompts the present article have chiefly in mind in making deductions for possible applications to their own uses. Admittedly, the way is open to fabricators for restricting the oxidizing influences when welding, but this is at a cost that may be beyond the ability of a great many of them to assume.

Without excluding oxygen from weld-content, one may deliberately introduce carbon to compensate to some extent for the oxidation of that element which inevitably occurs when a piece of metal containing carbon is melted and is exposed to ordinary atmosphere. Also one may, to some extent, introduce into the filled-in metal some proportion of silicon or of manganese. But personal experiments made by the writer of this article have demonstrated the poor success of these measures for maintaining practical similarity of chemical composition. One effect is to increase undesirably the area of the small bath of metal formed by the arc or by the gas torch. Another undesirable result is the formation of a greater amount of slag, very difficult to remove despite all the efforts to keep this non-metallic material from being confined and frozen in the joint or spot that is welded. These expedients, on the whole, have in the past produced more bad than good results. Such measures and others having for their purpose the betterment of the properties in the weld metal, have been zealously taken in many steel foundries, for a readily understandable reason. If plants of this kind were able to provide thoroughly satisfactory material in commercial welding, they would profit by a smaller percentage of discards from scrapped castings. Thus it is to the advantage of steel foundrymen to do what they can to improve the results from welding and to advocate the utilization of this fabricating method where it may be employed advantageously. The pocket-book of the steel foundryman is involved.

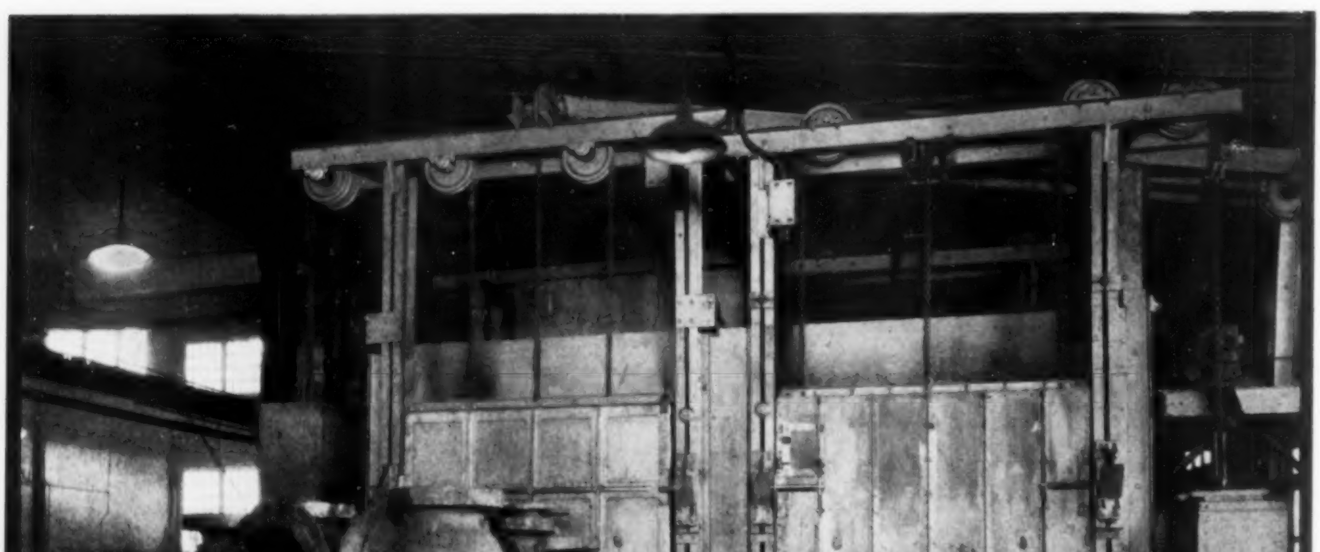
The writer of the article from which we quoted last has stated near the conclusion of his editorial effort that it is as "unfair and intemperate to say that all welds are bad, as it is to say that all welds are good." This statement precedes another, pointing out

that "means are available for separating the good from the bad." This sounds better than it is. The difficulty lies in obtaining a practical, economical means for separating the sheep from the goats. To some extent, that is the same difficulty applicable to the product of the steel foundry, and indeed the products of many other manufacturing plants.

There is no more reason for assuming soundness in a weld, whatever the metal may be, than there is for assuming soundness in a casting. There might reasonably be less justification for questioning the soundness of a casting than that of the welded piece. We believe this is the case in comparing parts welded manually in the customary way, with castings made by employing suitable pattern and other equipment, on a skillfully controlled production basis after preliminary precautions have been observed. Such try-out steps are taken regularly in properly conducted steel foundries before a production job is given the "go" signal.

The circumstances of manufacture have everything to do with soundness, whatever may be the metal part under consideration. And in that connection, it is difficult to think of any other metal manufacturing or fabricating process that is so dependent on the personal element for its quality as the ordinary welding operation. "Procedure-control" is a term that has been used probably with convincing effect to influence some to depend on welded structures. There are welding equipments of certain kinds which provide a considerable degree of control, automatically, without probable interference from a workman. The extent to which such control can deservedly be relied on by the man who uses the welded part where service conditions impose severe shocks or repetitions of considerable stresses, is necessarily determined by the degree to which the personal equation is absent. That applies to *(Cont. on page 128)*

Pressure Castings Ready for Heat Treating. This double chamber electric furnace is just about to receive a charge of steel castings destined for high pressure use. Good castings, properly treated, are widely used in pressure applications.



FINISHING STAINLESS STEELS

. . . . Pickling, Polishing, Welding

By C. C. Snyder
Abstract of Paper for
Western Metal Congress

SOMEONE has stated "there are as many brands of stainless on the market as there are five-cent cigars." This is somewhat exaggerated and might perhaps be reworded to say "as many brands as there are good five-cent cigars."

It seems that nearly every steel manufacturer has entered the stainless field making this or that analysis, all of them being sold under trade names. It is not too much to believe that the different types of stainless alloys will be standardized just as the S.A.E. steels are now, and a definite name or number will be given to each type of analysis.

It is but a matter of time until the public will demand that all bright and exposed parts of our motor cars will be of a rust-resisting metal. I believe that the fallacy of the statement that "stainless is too expensive for general usage" has been effectively quashed by one of the largest manufacturers of low-priced cars, who has switched entirely to stainless for bright parts. Its value for decorative purposes in the building trade is also being realized.

The various stainless alloys can be divided into four divisions as follows:

1. 10 to 15% chromium
2. 15 to 30% chromium
3. 16 to 20% chromium with 7 to 10% nickel
4. Chromium-nickel alloys not listed above, and those containing some of the following: Silicon, copper, molybdenum and tungsten.

What follows will be devoted to the manufacture and finishing of alloys of the third division, and more particularly the 18-chromium 8-nickel steel called Krupp-Nirosta KA2.

This is a single phase alloy — that is, its structure is austenitic and virtually non-magnetic. Because of its single-phase structure, KA2 should be and is admirably suited for maximum resistance to atmospheric and liquid (electrolytic) corrosion. It has remarkable ductility, showing Olsen cups of 0.450 to 0.575. Sheet and strip stock will give 40 to 50% elongation in 8 in. after a high heat treatment (the "Strauss" treatment) in excess of 2,012° F., followed by rapid cooling. If the object being annealed is light gage, such as sheet or strip stock, air cooling will suffice, but a heavy section should be quenched in water to avoid the possibility of carbide precipitation in the grain boundaries (which lessens greatly the ductility and corrosion resistance). Being an austenitic alloy it work hardens rapidly; however, subsequent high-temperature annealing removes all cold working strains.

Between 1,300 and 1,800° F. the ductility of this alloy is reduced. While this cannot be termed a "brittle" range, inasmuch as the ductility does not go below 40% in 2 in., still care should be exercised when the alloy is to be used in this range.

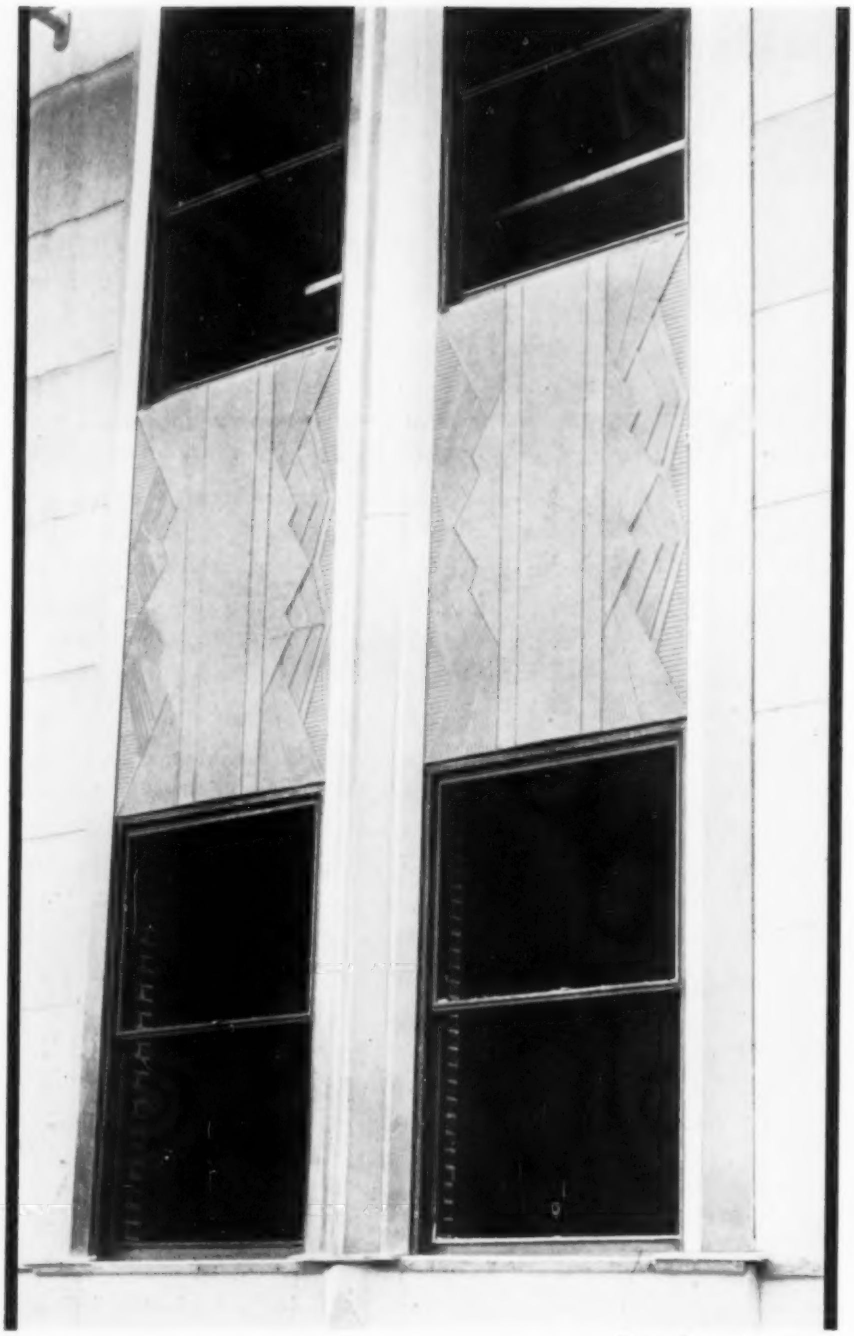


Photo Browning, N. Y.

Stainless Steel Window Trim and Pilasters on Empire State Building Furnished in Part by Central Alloy Division of Republic Steel Corp., and in Part by Allegheny Steel Co. Spandrels between windows are flat aluminum castings.

For most applications carbon of 0.07 to 0.16% is standard. For high-temperature work or for welded construction 0.07 carbon maximum is usually specified, because at temperatures above 1,100° F. and up to 1,700° F. very rapid carbide precipitation occurs. In order to combat this tendency, the carbon is lowered as much as is practicable, commercially, by using special low-carbon ferro-chromium in melting this type of heat.

The effect of carbide precipitation is shown by the photograph opposite of a welded pipe which was in service in a pickling tank. A region about ½ in. distant from the weld has been eaten away, while the weld proper and the rest of the tube are in good condition. During welding of the joint, the missing metal was between 1,100 and 1,700° F., while nearer the weld the temperature was in excess of 1,700° and the carbide was held in solution. It is quite obvious that for welded construction, where severe acid corrosion is to be encountered, material should be of the low-carbon type. A high-temperature quench, from 2,000° F. or higher, is necessary to replace the carbide into complete solution. Representative microstructures at 1,000 diameters are shown on page 80.

KA2 is being used extensively for nearly all types of corrosion, atmospheric and chemical, except in sulphur-bearing gases in excess of 1,200° F. The top temperature for scaling is 1,600° F., and it should not be above that except for continuous heating. Alternate heating and cooling will cause the protective scale (with a lower expansion coefficient) to flake off, causing loss of section and early failure.

The largest user of the low-carbon 18-8 analysis has been the oil refining industry. Cracking coils carry high pressures, and temperatures up to 1,300° F. are used. Crude petroleums are usually very corrosive, so we might say this alloy really performs three duties — strength at high temperature, resistance to scaling, and resistance to corrosion. Seamless tubes have been made with a wall thickness

of ¾ in. to withstand pressures as high as 3,000 lb. at high temperature.

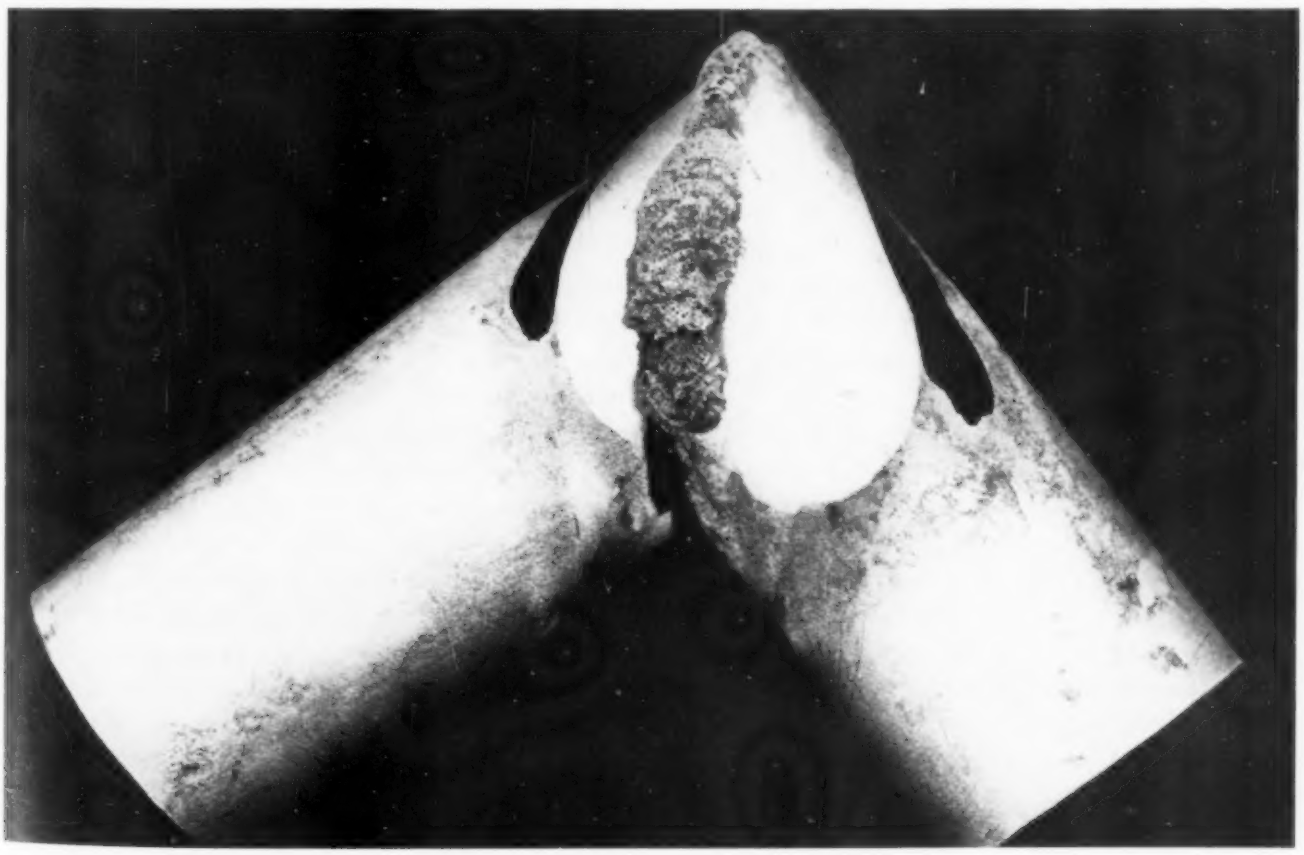
Not long ago a KA2-S tube was removed from a cracking still which had been in service for nearly two years and examined. There had been hardly any loss in ductility or strength as shown by impact and tensile test, and no carbide precipitation of a detrimental nature could be discerned. There had been a negligible loss of metal from oxidation or corrosion.

For drawing and forming KA2 sheets or strips, specially developed lubricants are advised. One of the most popular and widely used is a mixture of lithopone and linseed or paraffin oil. Other lubricants with special trade names are giving equally satisfactory results. If annealing must be done before drawing is finished, it is wise to remove the lubricant completely before placing the shape in the furnace, as some compounds will attack the surface.

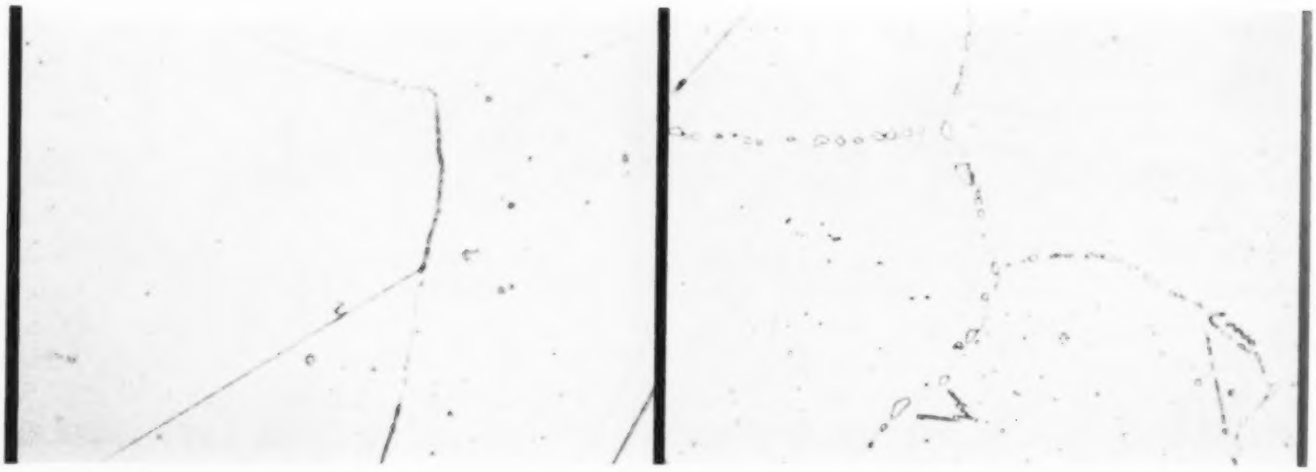
Pickling is best carried out as follows: Start with a solution of 6 to 8% sulphuric acid plus 4% hydrochloric acid, at a temperature of 130 to 160° F. It will loosen the scale. A mixture of nitric acid and hydrofluoric acid will then completely remove the scale without pitting or over-pickling. A third operation is sometimes added, particularly if the material is to be used in the pickled condition. This is the "nitric acid dip," which consists of immersing the material in a solution of 20 to 30% nitric acid at 125 to 150° F. for 30 min. The nitric bath will not attack the metal, but tends to give it a more passive surface, making it more highly resistant to atmospheric and liquid corrosion.

The general processing procedure of the chrome-nickel sheets used on the Empire State and the Chrysler buildings was as follows:

The sheets, after being hot rolled, heat treated and pickled, were rough ground with No. 80 grit, used dry, followed by successive grease wheels 100, 120, etc., until the finish desired was obtained. Sheets for the Chrysler building received a relatively high finish, followed by buffing and a nitric acid dip to render them passive. Sheets for the Empire State building had a medium finish, followed by a special wheel to dull the lustre to what is known as a "tampico finish." These sheets likewise were rendered passive.



Carbide Precipitation, During Welding, Caused Early Failure of this Pipe in a Pickling Tank.



Microstructure of Normal Austenitic Alloy Steel, and of Same Alloy With Carbides Precipitated at Grain Boundaries.

Then after being formed into panels at the fabricator's plants, they were again passivated in nitric acid immediately after the drawing compound was removed by gasoline and whiting.

This no doubt seems to be quite an expensive routine, but it should be remembered that steel dies were used for forming the panels, and abraded areas acquire a film which will rust rapidly. The nitric dip dissolves this.

For maximum corrosion resistance, particularly of the atmospheric and liquid types, stamped, drawn, rolled or forged objects of stainless steel should be ground and polished. The finish of the material in the sheet or strip form determines what grit should be used at the start of polishing. Pickle-finished material can usually be started at 150 or 180 grit. Cold rolled strip which has been pickled and then given a light skin roll will usually clean up with 180 or 200 grit.

Past experience has shown that the manufactured grits are quite satisfactory up to and including No. 180, but from there on the Turkish or black emery should be used. Do not use a buffing compound containing iron oxide, as it will promote corrosion. There are many special buffing compounds, most of them based on aluminum oxide or chromium oxide.

Polishing wheels should be of the soft cushion type and buffs should be well ventilated to lessen dangers of overheating.

Never use a wheel on stainless that has been previously used to polish steel or brass, unless thoroughly redressed. The danger of steel contamination has already been mentioned in the remarks about abrasion by dies. Brass can also cause disastrous results.

Several stainless automobile radiator shells had been formed and were being polished on the wheels formerly used for polishing brass shells. After the first operation, the stainless metal was found to be covered with numerous etching pits. The combination of brass particles, the heat generated on the polishing wheel, and the grease caused a corrosive action which in a few minutes ruined the stainless shell.

These high chrome-nickel alloys weld easily. The danger of carbide precipitation has been mentioned and can be taken care of by heat treatment or the use of low-carbon alloy. For electric arc welding rods of the same material having a special flux coating should be used. Polarity should be reversed — that is, the electrode should be positive and the work negative. Gas welding should be done with a slightly reducing flame.

Do not expect soldered joints to carry any loads. Soldering should only be used to make tight joints that have been riveted or lock seamed. When soldering the polished material, it is necessary to dull the surface before the solder will adhere. A satisfactory solution for this purpose contains 90 parts hydrochloric acid, 50 parts ferric chloride, and 3 parts nitric acid. Allow this solution to act for 10 min. or longer. To avoid staining after soldering, completely remove all traces of the acid by washing with bicarbonate of soda solution.

Correspondence . . .

Golden Gate
Photo by
Californians, Inc.

and Foreign Letters

Pipe Lines for Coke Oven Gas in Germany

Use of extensive pipe lines for utilizing natural gas is an old story in the United States, but the use of such pipe lines for artificial gas is not yet common. It may be of interest to hear that plans for building a gas distributing system for the whole of Germany are now being made, and that considerable progress has already been achieved.

The big coal fields in Germany are concentrated in a few districts, the main ones being the Ruhr in the northwestern part and the Silesian in the southeast corner of Germany. The intention is to build huge plants for producing coke and gas in these districts, possibly complemented by a few similar plants at strategical locations to which coal is shipped, and distribute the gas to consumers in all important German cities and industrial regions through high pressure pipe lines.

The economic reasons behind these plans are the desire to obtain in the big central coke plants a coke suitable for metallurgical purposes, and to find a profitable market for the considerable quantities of gas obtained in this process. It is claimed, however, that the transportation of heat in the form of gas can be achieved at such a low rate that it will compete in cost with its transportation in the form of coal by railroad.

It is admitted by the adherents of this plan that the gas, at present prices for coal and coke, will hardly be able to compete on a price basis with coal for the production of steam in boilers, yet for general household purposes as well as for metallurgical purposes, such as melting furnaces, heating furnaces for rolling and forging mills, hardening and drying furnaces, the delivery of a suitable gas can be made more cheaply than is possible from local gas works. Quite a few of the big steel mills in the Ruhr district are now buying gas from the central gas plants for such purposes as heating open-hearth and rolling mill furnaces.

Whole districts are already being served in the manner proposed for wider adoption. In one important German province, Westfalen, one firm has 228 km. of high-pressure and 848 km.

of low-pressure pipe lines. The sale of gas from this system was on the order of 26,000,000 cu.m. in 1929.

Another company has pipe lines with a total length of 950 km. The main line through Düsseldorf and Cologne is 800 mm. in diameter and has a yearly capacity of 500,000,000 cu.m. of gas. A similar line goes south from Dortmund and another toward the east to Hannover. It is planned later to extend the first mentioned line to the south border of Germany, serving many important cities *en route*.

The technical side offers no great difficulties. The gas is of good quality with a thermal value of 4,400 to 4,700 kg-calories per cu.m. The gas is cleaned from pitch, benzol and ammonia, and compressed. The usual pressure for the main pipe lines is at present 6 atmospheres, but in the projected line to South Germany the pressure will be raised to 15. Equipment for pressure regulation and measurement, as well as safety valves, are always included. The pressures are quite moderate, in comparison with those ordinarily used in American lines for natural gas.

The pipe is made of open-hearth steel with a tensile strength of 34 to 41 kg. per mm. (48,000 to 58,000 lb. per sq.in.) and elongation of 25%. The different pipes, 25 to 50 ft. long, are welded into 300-ft. lengths before being lowered into position in ditches about 5 ft. deep. Very little trouble is caused by breakage, and the leakage of gas is quite negligible. It is also said that compressors and other equipment give so little trouble that delivery of gas can be made with as much certainty as that of electricity or of coal by the railroads.

In the different cities, branch stations are erected where the pressure is reduced to one-half atmosphere, the usual pressure at which the gas is delivered to the customers. Big consumers, however, also use gas with a higher pressure direct from the line, and burners suitable for different pressures and purposes have been developed.

A few figures will show how rapid the development has been. In the Ruhr district in 1922 only 170,000,000 cu.m. was sold, but in 1929 it amounted to 1,010,000,000 cu.m. Even though the plans of covering all of Germany with a giant network of gas pipe do not eventuate, there is hardly any doubt about the economic and technical soundness of the plan, just as there is hardly any doubt about the soundness of the American super-power plan.

The similarity can be drawn still further. The many local political and business interests are, as a rule, hostile to plans of this kind, and it has also been feared that a monopoly of coke and gas may be formed. To overcome this resistance is the main problem with which the proponents of the major plan are now being faced.

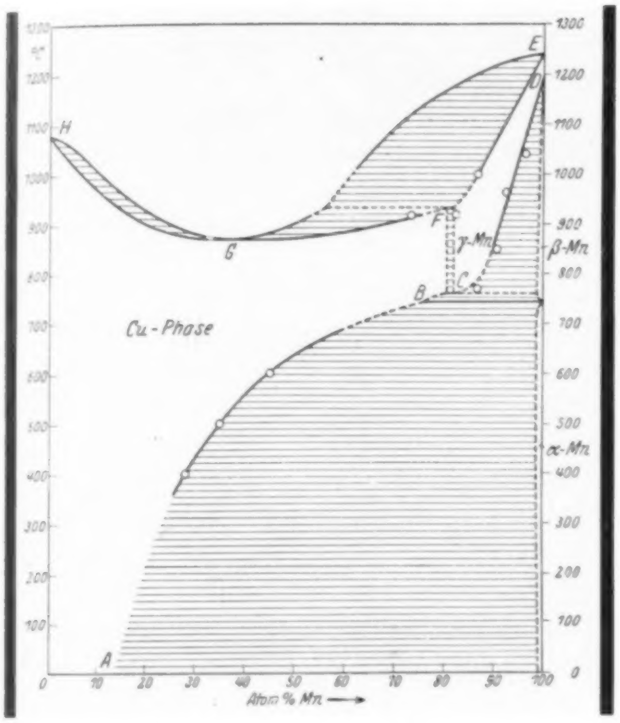
E. W. Ehn

Cannstatt, Germany

Suppressions in Alloys of Manganese

In the December number of Metal Progress was published an editorial note on present-day studies into the constitution of alloys, quoting a humorous remark by Dr. Mehl that many of the systems which have previously been considered to be quite simple have of late (by means of X-ray analysis) been proved actually to possess "lamentably complex tendencies and even suppressions." Indeed, we have had some experience of this fact in this country, and here, as in Pittsburgh, it is the manganese alloys above all that have shown the kind of symptoms mentioned in that editorial.

During the last winter Einar Ohman and Elis Persson of the University of Stockholm have investigated alloys of manganese with iron and with copper by means of X-ray analysis, and the reports of their work have been published in *Zeitschrift für Physikalische Chemie*. As may be seen in their equilibrium diagrams, reproduced on page 87, the alloys in question, especially those of iron and manganese, certainly have the very "complex" tendencies mentioned by Dr. Mehl.



Copper-Manganese Equilibrium Diagram, According to Persson

During his investigation of the last-mentioned system, Ohman has also struck upon a phenomenon that might be termed a "suppression." In agreement with observations of W. Schmidt in Germany, iron-manganese alloys containing about 20% manganese were found to consist of solid solutions of manganese in α- and γ-iron mixed with a certain amount of a third phase, ϵ, having a close-packed hexagonal structure. According to Ohman, the latter seems to have no temperature-concentration area in the diagram at ordinary pressure within which it is really stable. It is evidently formed only intermediately, when the solid solution of manganese in γ-iron is transformed into α-iron supersaturated with manganese. Since the reaction velocity of this process probably is low, the ϵ-phase is thus very likely a suppressed transformation.

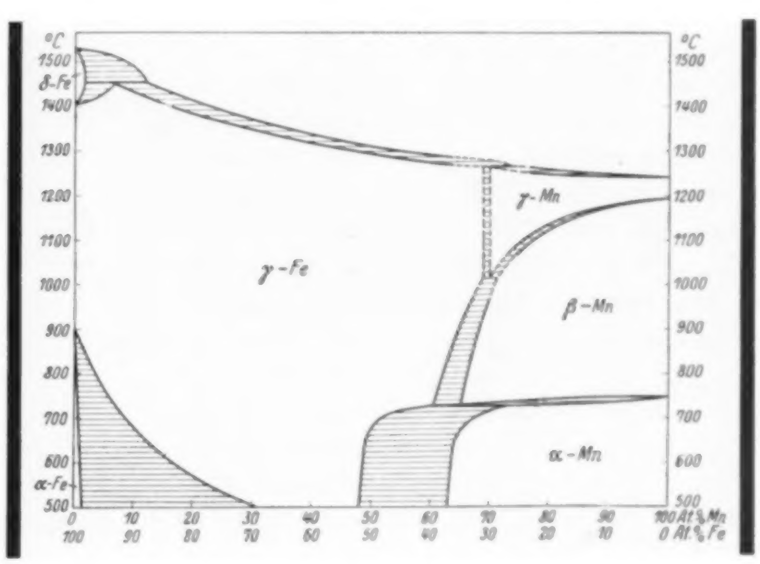
The stable phases of the solidified iron-manganese alloys are all solid solutions, either of manganese in α-, γ- or δ-iron, or of iron in α-, β- or γ-manganese. As there is no intermediate phase present in the copper-manganese system either, and as copper has no allotropic change, four solid solutions exist in the latter.

It is, however, a question of some doubt if the narrow vertical two-phase strips separating the pairs of γ-phases in the two diagrams should not really be eliminated. As may be seen, their limits have been drawn as dotted lines in the figure, showing that their reality is considered uncertain. The crystal structure of γ-manganese resembles very much that of γ-iron and that of copper, being close-packed tetragonal with an axial ratio of 0.934. When iron or copper is dissolved into this phase, the atomic grouping of the solid solution formed is continuously approaching the cubic arrangement of the γ-iron or of the copper phase. Ohman and Persson have not been able to find any discontinuity in the X-ray evidence during the transition from the tetragonal into the cubic states of the solid solutions.

These facts constitute phenomena of considerable theoretical interest, and will no doubt be the subject of important future work.

A. Westgren

Stockholm, Sweden



Iron-Manganese Equilibrium Diagram

A Note On the Formation of Nodular Troostite

IT IS WELL known that nodular troostite in carbon steels is formed only during the process of quenching, but the question, "Why does it develop into such a form?" is not yet satisfactorily solved. From the curves obtained with his self-recording dilatometer (described in METAL PROGRESS last month) Mr. S. Sato has answered the above question in the following way:

Since it has been shown by K. Honda and K. Iwase, in *Transactions*, A.S.S.T., in 1927, that the change of austenite into martensite is accelerated by an internal stress, it may be expected that during the transformation the martensite is at first formed at several centers located in the grain boundaries of the mother austenite.

This is a reasonable supposition because the crystal lattice in the boundary is much more distorted than the lattice within the grains themselves, by virtue of the presence of foreign atoms of impurities, and, therefore, the internal stress will be especially large at these loci in the boundary.

Consequently, when a portion of the lowered Ar_1 transformation begins to take place in a range of 600° to 500° C., (which is the recrystallization temperature of a strained α-iron, according to E. Sheil in *Anorganische und Allgemeine Chemie*, 1929), minute portions of austenite at several spots in the grain boundary will first transform into martensite, but this latter is immediately decomposed into cementite and α-iron at the high temperatures. The latter, being strained by the change, begins to recrystallize, and thus the characteristic pattern of martensite is destroyed.

This process goes on from several nuclei here and there in the boundary, where the stress is especially large, in every direction independent of the orientation of the mother austenite, resulting in a structure which we call the nodular troostite. If this structure is examined with a high-power microscope, it reveals a structure with lamellar pearlite radiating from a central spot. Thus the microscope shows that the above view is correct.

It has been proposed by some metallurgists that nodular troostite is formed by a direct precipitation of cementite from austenite, without passing through martensite; this view is based on the fact that a troostite having a martensitic needle pattern can never be seen in quenched steel. But the absence of this form of troostite in quenched specimens is satisfactorily explained in the above way, and therefore, this view cannot be correct. In fact, as shown by the writer in the *Transactions*, A.S.S.T., in 1929, the direct change of austenite into a mixture of α-iron and cementite — troostite — is by no means theoretically possible. Also, the reason why austenite, during rapid cooling, is especially stable between 500° and 300° has already been explained by K. Honda and J. Kikuta, in 1922 in *Science Reports* of the Imperial Japanese University.

K. HONDA

Sendai, Japan

Pure Aosta Ore Makes Steel of Highest Quality

ON ACCOUNT of the peculiar conditions under which special steels are manufactured in the works of the Cogne Co. — the exceptional purity of the raw materials and the manufacturing processes I have described in my last letters — it is perhaps interesting to point out briefly the results obtained.

The advantages due to the exclusive use of the iron produced from the Cogne ore, and the complete elimination of scrap, have been clearly proven, since the same electric steel furnaces were used before the erection of the blast furnaces and the converters. During these early months they were used for melting mixed charges of pig iron and high quality commercial steel scrap. Differences in quality of product, then and now, are therefore principally due to differences in raw material.

In a general way, the total elimination of best quality commercial steel scrap and the exclusive use of the Aosta iron, partially blown in the converters, has given technical results similar to those obtained in several works where the scrap was replaced by Swedish sponge iron. In all the grades of steel so manufactured great increases in the impact value, resistance to fatigue, elongation, and of uniformity were immediately noticed. This held true even when very large tonnages were produced.

Obviously, such improvement should be attributed, like those noticed when sponge iron replaces scrap, to the complete absence of certain metals and impurities, such as copper, nickel and arsenic, which are always contained to some slight extent even in the best commercial steel scrap. These impurities are present in highly variable and non-controllable proportions. The advantage of eliminating them entirely has been dwelt upon at length by those who have investigated the advantages of using sponge iron for raw material in steel making.

It is perhaps interesting to note that by duplexing the pig iron obtained from the Cogne ore, it is extremely easy to deoxidize and purify the steel in the last part of the electric furnace treatment. Furthermore, purification is substantially complete. This shows that the oxides and the silicates produced in the converter have a strong tendency to coalesce and to come to the surface of the metal when a proper refining treatment is given in the electric furnace.

In addition to a notable improvement in the general mechanical properties, the exclusive use of the Cogne iron has effected great improvements in many special qualities. These are particularly felt in certain grades of steels and in certain special applications. A few examples may be quoted:

There is a remarkable absence of any tendency toward the formation of forging and rolling cracks, even in steels usually showing such a tendency in a marked degree.

The Aosta steels show an almost utter absence of any tendency to what is usually called "aging;" that is — a more or less slow change of the mechanical properties after cold work, whether followed by other treatment or not.

Another property of great practical value is the exceptionally wide safety range in hardening temperatures — often wider than for the best tool steels made from the purest Swedish raw materials.

Finally, an exceptionally good weldability is a typical quality of these steels.

The above mentioned properties and many others which cannot be mentioned here for the sake of brevity, fully confirm what has been shown in a smaller scale by recent researches on steels manufactured from the purest Swedish sponge iron. Of course it should be evident that the process followed in the Aosta works is much more economical than present processes based on the use of sponge iron.

These exceptionally good qualities of the Aosta steels make it possible to pour special steel castings which show, after proper heat treatment, very high mechanical properties, even comparable to those of the best forgings. This fact, combined with the relatively low cost of such steels, is leading many engineering works to replace certain forgings with steel castings, to their advantage both technically and economically.

FEDERICO GIOLITTI

Turin, Italy

Research Groups Receive Government Aid in England

BECAUSE the necessities of the War showed the need of systematic organization of research for the benefit of industry, the British Government established in 1915 an Advisory Council for Scientific and Industrial Research, composed of eminent scientific men with an administrative chairman. It is largely due to the ability of that chairman, the late Sir William McCormick, that the success of the scheme is due.

It was soon found necessary to establish a special department, and a grant of one million pounds was made by Parliament for the provision of grants for research. While the practice of assisting individual workers in pure science was continued, a special scheme was devised for the assistance of industry. Any industry desiring to share in the advantages of the scheme was required to form a Research Association, raising funds by means of a levy on its members, based usually on output or on wages bill. Membership of such associations was entirely voluntary, but in the case of highly organized trades, it was found possible to include nearly the whole industry. The more scattered and the smaller the scale of the units, the more difficult it was to unite all the manufacturers.

Once a satisfactory scheme has been devised, the Department makes a grant of money for an initial period of five years in each case, usually equal in amount to the sum raised by the Association from its members. Although the programs of research have to be formally approved and the accounts audited by the Department, the administration of the scheme is highly elastic, and commendably free from bureaucratic interference.

At the end of the five-year period, the working of each Association is thoroughly reviewed by a commission of experts. The practice has been, in the case of a favorable report, to renew the grant for a further period, but usually on a progressively diminishing scale, with the object of encouraging each association to become self-supporting, although it is recognized that some measure of government help may be required for some years yet.

The organization of the research work takes different forms in different industries. Thus, the Cotton Research Association has large central laboratories near Manchester, with a scientific staff for work in physics, chemistry, botany and other related subjects, while the Non-Ferrous Metals Association has only small central laboratories and has most of its investigations carried out in public institutions, such as the National Physical Laboratory and the Woolwich Research Department of the War Office, or in university laboratories up and down the country, where the supervision of the work is entrusted to the professor in charge.

Each association has a director of research, whose business it is to coordinate the investigations on its program, and in addition to a technical and library staff, usually one or more development officers charged with the task of making the information gained as immediately useful to the members as possible. The results are communicated to members in the form of bulletins, but much of the work ultimately appears in contributions to technical societies.

What has been accomplished is best seen from a study of the annual reports of the Associations. The Non-Ferrous Metals Association, one of the most enterprising and successful of all, has a fine record of work to show. Improvements in cable sheathing, in condenser tubes, and in the elimination of gases from cast metals are among its most conspicuous successes. The Cast Iron Association has made progress in raising the standard of foundry methods, and in the development of special irons for resistance to heat and to corrosion, while its studies of molding sands have proved of great immediate advantage to the industry.

The steel industry, being largely in the hands of great undertakings having their own research laboratories, did not form an association on these lines, but cooperative work has been in progress for some time under the direction of committees of the Iron and Steel Institute, a scientific body without commercial ties. Among these were the well known committees on the heterogeneity of ingots and on corrosion.

In 1929, however, the National Federation of Iron and Steel Manufacturers, together with the Iron and Steel Institute, formed an Iron and Steel Industrial Research Council, which raises funds and receives government assistance in similar manner to the associations, and now makes itself responsible for the committees just mentioned, and for other activities (such as the Blast Furnace Coke Committee, the first publication of which, a substantial volume containing

the results of work on coke carried out in Sheffield University, has just appeared). Technical and academic workers sit on all these committees and the relations between the two have been most harmonious.

The system inaugurated during the War has thus proved its value, and has given an important stimulus to scientific research in its application to industry.

Cecil H. Desch

Sheffield, England

French Furnaces Supply Energy of Super-Power

We have already shown in a preceding letter the development and triumphal progress of the electric furnace, as well as the part it took in the modern evolution of French steel making. But if electricity is a form of energy particularly adapted to the metallurgy of iron, contrariwise, we must note that the metallurgy of iron is one of the most important aids to electrification, the blast furnace being not only an iron producer, but also an energy generator.

The part taken by energy in the metallurgy of iron involves the problem of the electric inter-connection of metallurgical works. A remarkable example of this is given by works in the Briey district.

Of the 20 works situated in France, which include 100 blast furnaces producing 7,000,000 tons of iron per year, the power supply of ten of the works (with 60 furnaces) has already been inter-connected. The distance existing between the farthest works does not exceed 60 km., yet the power system carries a voltage of 65,000 over a great loop, completed by a diametrical cross-connection. A 30,000-volt network is used between mines and works of less importance.

Actually, the total capacity of the ten connected central stations is approximately 125,000 kw., produced by five four-cylinder gas engines (22,000 kw.), 20 two-cylinder ones (50,000 kw.), and 15 steam turbines (45,000 kw.). Besides these, six electrical converters supply other works wired for continuous current, and their capacity reaches 30,000 kw. The total capacity of the 40 sundry units includes 56% gas engines, 36% steam turbines and 8% converters.

The success is measured by the energy interchanged which, from 8,000,000 kw-hr. in 1923, has increased to 137,000,000 in 1929, and will reach about 200,000,000 in 1931. This energy is obtained from gases which were previously lost, and it produces an annual revenue approaching 20,000,000 francs.

The electrical interests which made the connection, had to look for new customers, chiefly for night or off-peak energy. Being already connected to the great distributing network in Alsace, Lorraine and Vosges, it has recently organized two new firms to erect high-tension lines to add the metallurgical works in the Parisian region, and in the Ardennes.

Albert Portevin

Paris, France

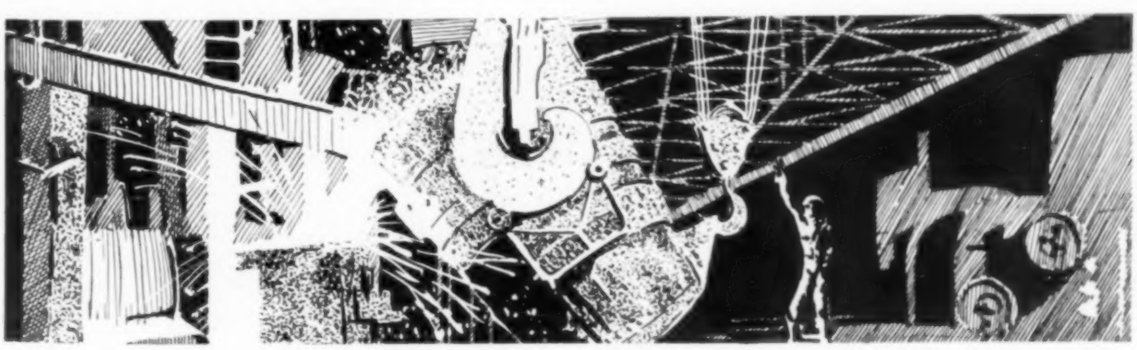



Photo by John P. Mudd for Midvale Co.

Hot Slag from an Open-Hearth

The following abstract is a condensed version of a paper entitled "The Formation and Elimination of Non-Metallic Inclusions in the Acid Open-Hearth Process" contributed to the Western Metal Congress by the Pittsburgh Experiment Station of the U. S. Bureau of Mines. It is printed by permission of the Director of the Bureau and is not subject to copyright. The entire text is available in pamphlet form, and copies will be sent to members of the A.S.S.T. on application. It will also be published in full in the next volume of Transactions.

CLEAN STEELS

. . from Acid

Open-Hearth

By C. H. Herty, Jr., and J. E. Jacobs

IN FEBRUARY, 1930, a cooperative agreement was made between the U. S. Bureau of Mines and the Heppenstall Co. of Pittsburgh, Pa., to study the acid open-hearth process. Two grades of alloy steel of the following percentage analysis were chosen for the investigation:

Constituent	Grade 1	Grade 2
Carbon	0.28 to 0.33	0.52 to 0.57
Manganese	0.60 to 0.80	0.55 to 0.70
Silicon	0.20 to 0.30	0.20 to 0.30
Nickel	1.5 to 2.0	1.5 to 2.0
Chromium	0.60 to 0.80	0.60 to 0.80
Molybdenum	0.40 to 0.50	0.20 to 0.25
Vanadium (min.)	0.15	0.15
Phosphorus (max.)	0.040	0.040
Sulphur (max.)	0.040	0.040

The six factors to be studied were:

1. The elimination of non-metallic matter originating in the charge and from the furnace lining

2. Oxidation of the metal during the working of the heat

3. Deoxidation with ferrosilicon and ferromanganese and with special manganese-silicon alloys

4. Elimination of silicates in the ladle

5. Segregation of non-metallic matter in the ingot, and

6. Slag-metal reactions.

Experimental work is being carried out in the 20-ton furnaces of the Heppenstall Co. The average weight of metal tapped is 57,000 lb. The hearth is 18 ft. long and 7 ft. wide, and the furnace is oil-fired.

To date, the first four items have been studied in detail.

Since the acid open-hearth process has been reviewed most completely by H. P. Rassbach in *Transactions*, A. S. S. T., vol. 15, 1929, the writers will give only a brief outline of this phase.

The Charge. A high percentage of manganese is desirable in the charge, because during the melting period a large part of it is oxidized and gives a clean slag. Frequently, spiegel or ferromanganese is charged to bring the percentage up to 1.0% or more.

As a rule, the charge is made up to contain about 0.75% of silicon for the three following reasons:

1. The oxidation of silicon is an exothermic reaction and facilitates the melting of the charge.

2. A considerable amount of FeO is produced on melting from oxidation of the scrap by the flame and from the rust in the charge. If there is not sufficient silicon in the charge to take care of this FeO, the furnace banks will be badly attacked.

3. If the silicon did not use up this FeO in the charge the bath would melt down wild, and the carbon content of the bath would be below the percentage desired at melt-down.

Melting. When the charge is melted, the bath contains an average of 0.15 to 0.25% silicon and 0.15 to 0.30% manganese. In addition, there is usually present 0.50 to 0.75% carbon in excess of that required in the finished product. Below are two typical slag analyses at melt-down (wherein total iron is given in terms of FeO).

Type of heat	FeO	MnO	SiO_2	CaO
0.55 C	19.72%	23.60%	54.88%	0.74%
0.30 C	26.44	19.53	51.40	0.46

Carbon is eliminated by reaction with iron oxide,

$$C + FeO \rightleftharpoons CO + Fe.$$

However, before the carbon can be removed the residual manganese and silicon must be reduced to a value below 0.10%, because at higher contents of silicon and manganese the iron oxide content of the bath is too low for this reaction to proceed. Elimination of silicon and manganese is accomplished by the iron oxide resulting from oxidation during melting in the interval between melt-down and the first ore addition, by the following reactions:

$$Si + 2FeO \rightleftharpoons SiO_2 + 2Fe,$$

$$Mn + FeO \rightleftharpoons MnO + Fe.$$

The main purpose of this interval is to get up temperature in the furnace and have the bath as hot as possible.

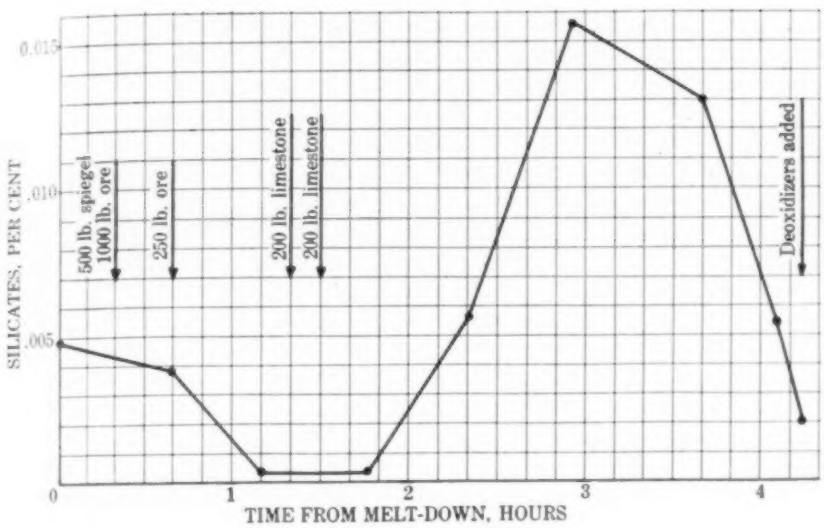
Working the Heat. After the residual manganese and silicon have been reduced and the proper temperature has been attained, the steel is ready to be refined.

As soon as the ore addition has been made (the general practice in this country has been to use small amounts of ore) a vigorous boil ensues, and the carbon begins to drop rapidly. When the fracture test reveals that the carbon content is approaching that desired in the finished product, ferrosilicon and ferromanganese are added, which prevents further oxidation of carbon by the iron oxide. After the report has come from the laboratory that the carbon is at the desired point, the various alloys are added at definite intervals, usually about 10 min. After the final manganese addition the heat is held in the furnace about 15 min. before tapping to make certain that all the alloys go into solution. The heat is then tapped. In acid open-hearth operation it is advisable to make all deoxidizing additions in the furnace and as few as possible in the ladle. In contradistinction to basic open-hearth practice, the alloy losses are smaller in the acid open-hearth because the slag is so much less oxidizing toward the metal.

Elimination of Non-Metallics. Due to the difference in opinion as to the amount of ore to be used, this investigation includes heats which were worked with no ore addition, with very small and with relatively large ore additions.

From a theoretical point of view it seems reasonable that a large ore addition should be most advisable. In the bath after the silicon has been oxidized are a large number of small glassy silicate particles. To aid in their transfer from the metal to the slag, some action must take place, and the most logical agent to produce this action, as a lime boil is impossible, is an ore boil. For this purpose, large lump ore is the best because it causes a much more violent boil than the small ore. On heats which melt down low in silicon, a vigorous action commences as soon as the heat is melted. These heats require less ore to obtain the desired action than those melting down higher in silicon. The amount of ore to be added is therefore left to the judgment of the melter.

There is one more factor that facilitates the removal of silicate particles, and that is a fluxing agent. For this purpose some oxide such as MnO should be formed in the bath at the time of the ore addition. The oxides SiO_2, MnO, and possibly some FeO would then combine, form



Silicate Content of Acid Open-Hearth Bath During Working Period

is very little silicon in the bath which can be oxidized to SiO_2. This would indicate that the various grades of sand used for bottom material and the various methods of burning in the bottom materially affect the cleanliness of the steel during the working period.

Oxidation During Working the Heat. On all the heats stud-

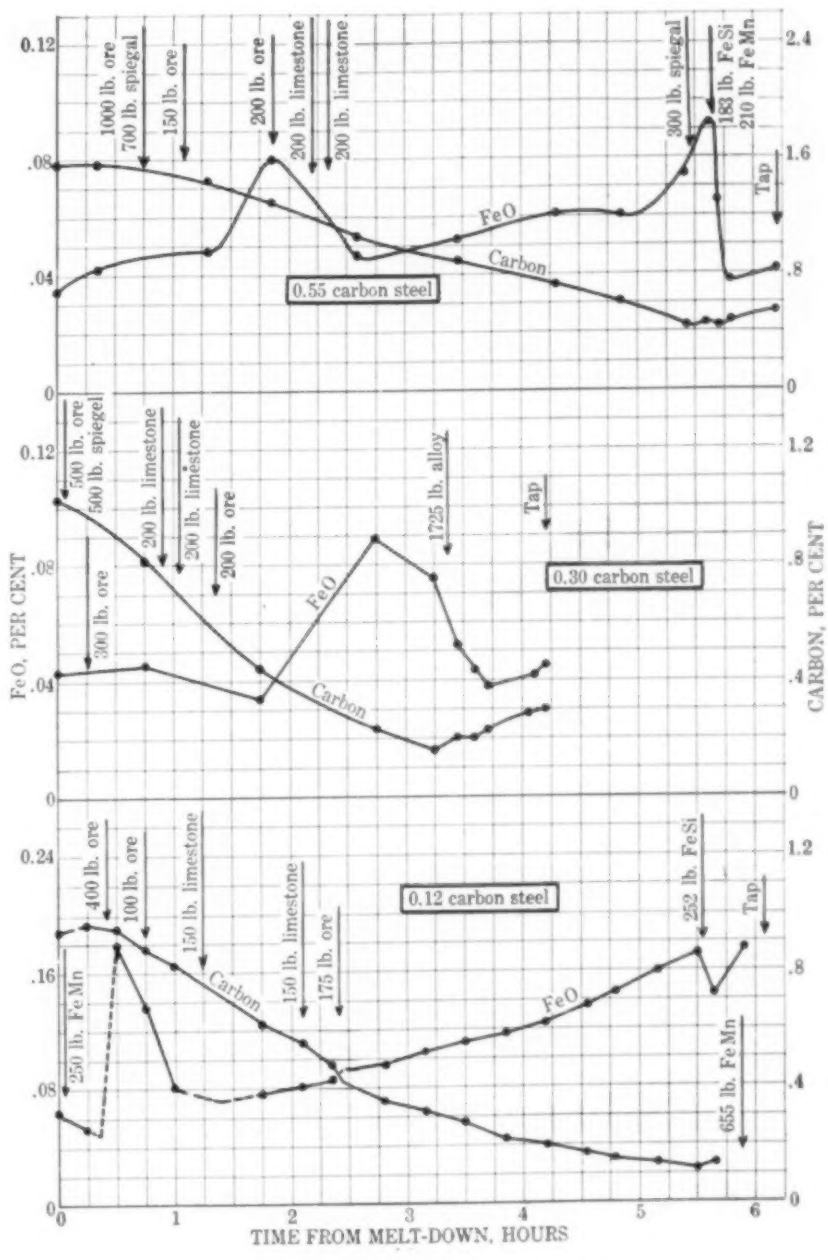
large globules, and have a much greater tendency to rise to the slag during the boil than would the small SiO_2 particles alone. Following this line of reasoning, a spiegel addition of approximately 50% of the weight of the ore is added to the bath just before adding the ore.

Average content of non-metallic matter in steel worked with ore alone and with ore and spiegel is shown below, and proves the advantage of using ore and spiegel. On two of the heats worked with ore and spiegel there was no visible non-metallic matter one hour after the ore addition.

	Before addition	1 hr. later
Heats with ore alone	0.008	0.003
With ore and spiegel	0.006	less than 0.001

About 1 to 1½ hr. after the ore addition, the steel begins to "dirty up" again. The figure at the top of this page shows that the pick-up of non-metallic matter shows a maximum and that the heat is cleaning up at the time of deoxidation.

It would seem that this increase in non-metallic matter comes from bottom materials. The inclusions are exceptionally small and very high in silica, and there



Iron Oxide in Acid Open-Hearth Steel

Photo by Erik Walldow

Pouring Four Crucibles of Metal Into Steel Ingot; Vikmanshyttan, in Central Sweden

ied by us, iron oxide in the metal was determined by the aluminum method described in Technical Publication No. 311, American Institute of Mining and Metallurgical Engineers. The oxidation curves shown on page 95 for the 0.55 and 0.30-carbon grades have been corrected for visible non-metallic matter, whereas the oxidation curve for the low-carbon heat has not been so corrected. However, the corrections are small enough on the higher carbon steel that they amount to very little on the high iron oxide of the low-carbon steel heat.

As would be expected, the oxidation of the heat increases as the carbon drops, although this is not as pronounced on the high carbons as on the low-carbon heat. The factors affecting the oxidation of the metal are (1) the carbon content; (2) the slag composition; (3) the slag viscosity; and (4) the temperature. The oxidation of the metal in the low-carbon heat when it contains 0.30 and 0.55 carbon is greater than on the higher carbon grades because the slag was kept much more highly oxidizing so that the heat could be brought down to 0.12 carbon as rapidly as possible.

In basic open-hearth practice the iron oxide content of the metal very seldom decreases unless a deoxidizer is added. On the other hand, in acid operation such a drop has been noted before the addition of the deoxidizers. This drop is caused by the change in slag composition and viscosity. As the slag picks up more and more silica from the furnace lining, the free iron oxide content decreases and the viscosity of the slag increases. Both of these factors tend to decrease the rate of diffusion of iron oxide from slag to metal, and as the carbon reaction is proceeding at all times, there is necessarily either a decrease in the rate of pick-up of iron oxide or an actual decrease in the iron oxide content of the bath. The average iron oxide content of the metal before deoxidation was 0.054% for nine heats of the 0.55% carbon

grade and 0.076% for three heats of the 0.30 carbon grade. The single heat of 0.12 carbon steel showed 0.17% iron oxide. As the carbon drops, there is more and more iron oxide to be deoxidized, which, with normal deoxidation practice, would result in more and more nonmetallic matter in the final product. It will be noted, however, that the change from the low-carbon steel to the 0.30 carbon steel is more pronounced than the change from the 0.30 to the 0.55 carbon steel, a fact which is in accord with theory and which has also been noted in basic open-hearth work.

Deoxidation with Alloys. Before discussing deoxidation, it is necessary to remark on the condition of the slag throughout the heat.

Slag viscosities were measured by the inclined-plane method used at Pittsburgh and described in Cooperative Bulletin No. 38, Carnegie Institute of Technology, 1930. To measure this property, a spoonful of slag is taken from the furnace, and poured on an inclined steel plate. The slag freezes, and the thickness at an arbitrarily chosen point is measured in millimeters. This thickness is a direct indicator of the true viscosity of the slag.

It is very important that the slag have the proper viscosity when the heat is ready for deoxidation. If the slag contains only silica, iron oxide and manganese oxide, there is a very sharp change in viscosity at 56 to 58% silica. On the other hand, if lime is added to such a slag the change in viscosity is not so sharp and the viscosity is more easily regulated. Hence, after the ore has worked through the bath, and the slag is thin and watery, 200 to 400 lb. of limestone is added to the slag, depending upon its condition at that time. From then on until the heat is tapped, the viscosity is watched very closely, for great care must be taken to see that the slag does not become too heavy or viscous, because if this happens the non-metallic matter in the bath at this time and also the products of deoxidation do not have much chance of entering the slag. Moreover, a heat tapped with a heavy viscous slag usually shows a "kick-back" of inclusions in the ladle. Thus, before any final additions are made to the heat, if the slag has a tendency to become heavy and viscous, a few shovels of fine ore dust, manganese dust, or scale are scattered over it until it reaches the desired viscosity. Burnt lime is much slower than the materials mentioned.

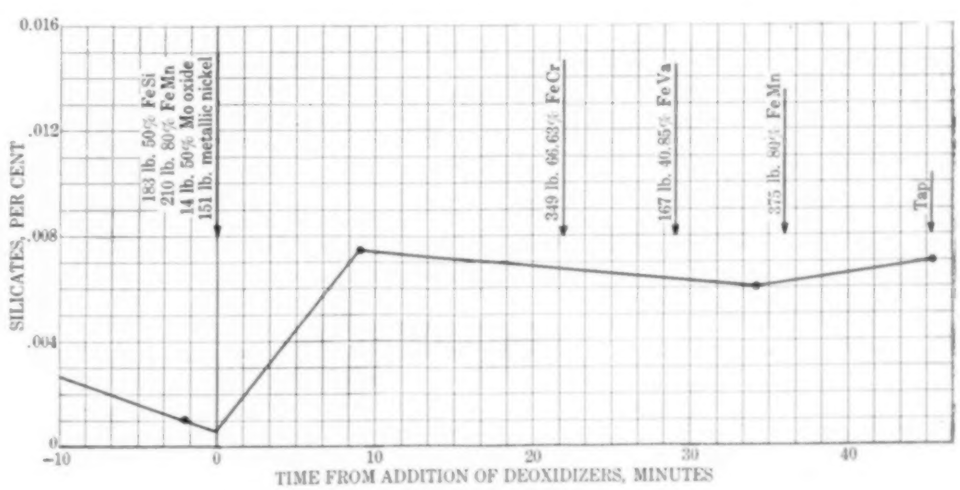
If the slag has been worked properly, the only danger which the operator faces is that it may become too heavy through excessive erosion of the furnace lining. However, if the slag should be too thin before deoxidation, which is highly improbable, it may be thickened by either dropping the temperature slightly or adding silica sand.

The average composition of slag and metal found just prior to deoxidation is:

	Slag				Metal		
Grade	FeO	MnO	SiO_2	CaO	C	Mn	Si
0.55 C	15.66	20.79	55.00	4.88	0.49	0.17	0.10
0.30 C	18.88	18.14	55.10	4.12	0.17	0.10	0.08

Slag analysis given above for the 0.55% carbon grade includes heats deoxidized with ferrosilicon and ferromanganese, and with the manganese-silicon alloy. Slag analyses were essentially the same for both types of heats. However, the heats deoxidized with the alloy were killed at 0.45% carbon instead of 0.49 on account of the higher carbon content of the alloy.

On the 0.30% carbon grade the carbon con-



Deoxidizing 0.55 C Steel With Ferrosilicon and Ferromanganese

tent is lower at deoxidation than would normally be expected for the same reason.

It will be noted that the slags on the lower carbon heats contained more FeO and less MnO than higher carbon heats — a natural result of oxidation by the furnace gases. Manganese and silicon is lower in the lower carbon grade for reasons already indicated.

If the reaction $FeO + C \rightleftarrows CO + Fe$ is allowed to proceed indefinitely, the carbon content of the steel will fall to a very low value, the amount of iron oxide increase, and the metal after solidification would contain large gas holes caused by the evolution of CO.

To avoid these conditions, the heat is "tied up" after the carbon has been lowered nearly to specification, so that the excess SiO_2 in the slag is reduced (causing a pick-up of silicon in the metal), or deoxidizers are added (which form more stable oxides, practically insoluble in steel, and only slightly reduced by carbon).

What happens after "tying up a heat" is not known, with precision. One school believes the following reaction takes place between the metallic iron and the SiO_2 in the slag:

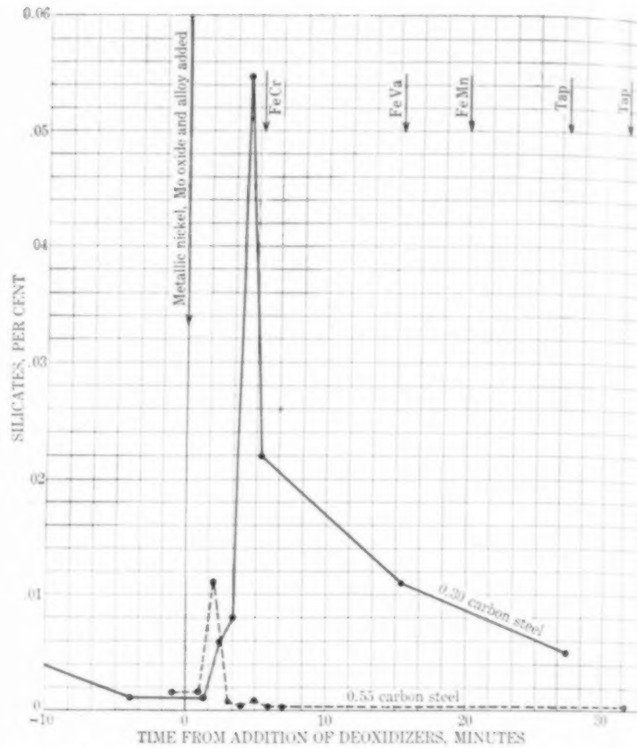
$$SiO_2 + Fe \rightleftarrows FeSi + O_2$$

If this is true, this excess SiO_2 is reduced by the iron, and the oxygen liberated from the SiO_2 perforates the metal. In the furnace bath where the slag is only in contact with the surface of the molten metal, the oxygen liberated will pass off as nascent oxygen.

Others disagree, and believe that with steadily increasing temperature the oxidation of Si is first checked and then held. Finally (due to the high temperature and the large excess of SiO_2 in the slag) the affinity of C for O_2 increases to the point where it will reduce the Si out of the SiO_2 according to the reaction $2C + SiO_2 \rightleftarrows Si + 2CO$. This leaves the Si free in its nascent state to deoxidize the steel.

Few experimental data are available to indicate which theory is correct. However, it is a known fact that the reaction $SiO_2 + 2Fe \rightleftarrows Si + 2FeO$, takes place at steel-making temperatures. As the temperature increases, the per cent of SiO_2 in the slag increases while the per cent of FeO decreases. This means that the silicon content of the metal must increase.

Also, since the reaction $2C + SiO_2 \rightleftarrows Si + 2CO$ takes place at very high temperatures, it is quite probable that this reaction is beginning to take place at steel-making temperatures. Both reactions are possible and there is every reason to believe that both operate simultaneously, as high temperatures favor the reduction of silicon by each reaction.



Elimination of Silicates After Adding Manganese-Silicon Alloy

The first heats made in this investigation were deoxidized in the furnace with 50% ferrosilicon and ferromanganese. The formation and partial elimination of the oxides formed are shown in the curve on page 97, which shows that there was a considerable amount of non-metallic matter left in the steel when the heat was ready to be tapped. The maximum amount present was probably not observed because too much time was allowed between the addition of the deoxidizer and the taking of the first sample. Oftentimes the maximum dirtiness of the steel has not been reached until just before tapping time. This allows very little time for any cleaning action to take place in the furnace; consequently, the finished steel contains an appreciable amount of non-metallic inclusions.

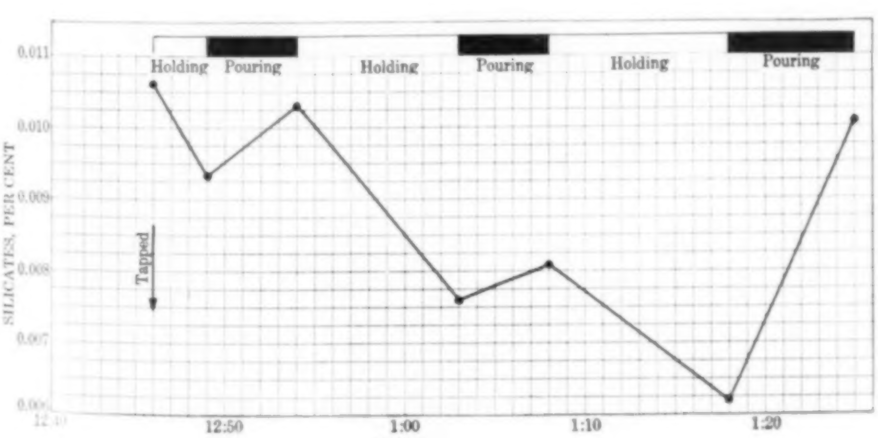
Later, 11 heats were made which were deoxidized in the furnace with an alloy developed at the U. S. Bureau of Mines in connection with

the program on the physical chemistry of steelmaking. This alloy contained approximately 31% manganese, 4.9% silicon, and 2.4% carbon. Generally about 0.15% silicon is added in the form of the alloy.

Elimination of silicates on the two grades of steel deoxidized with this alloy is shown on page 98. The alloy has a lower melting point than ferromanganese and ferrosilicon separately, and goes into solution much more readily, killing the heat almost instantly. The types of inclusions formed are much larger, and rise out of the bath with surprising rapidity. From this time on to tap, the smaller particles which have not risen out of the bath have an opportunity to do so. The net result is that the tapping tests are very much cleaner. Comparative figures on silicate content are 0.010% and 0.001% (in 0.55 carbon grade).

As the investigation proceeded it was found advisable to add about 0.40% of manganese, as ferromanganese, about 10 min. before tapping, which aids materially in cleaning the bath. This practice gives a steel which is clean not only of deoxidation products, but of any oxides which come from the charge or from the furnace bottom.

The finishing slag has a considerable influence on the cleanliness of the steel in the ladle. If it is extremely viscous, the non-metallic matter floating just under the slag surface is mixed with the remainder of the metal on tapping, and the net result is a dirtier steel in the ladle than was observed from furnace tests. When slag has a viscosity of 4.0 to 4.5 mm., no such kick-back occurs.



Elimination of Silicates During Pouring

Clean-Up in the Ladle. While the steel is held in the ladle, some of the inclusions present have a chance to coalesce and rise to the slag-metal surface. The figure below brings this out.

The silicate content of the steel shows a decrease immediately after tapping. While the first ingot was being poured, the level of the steel in the ladle dropped, and the inclusions were overtaken in their ascent. Similarly for the second and third periods. The reason for this marked rise during the last pouring period is that this sample represented the last metal poured and was very close to the slag surface. This curve shows the advantage of holding the ladle before starting to pour.

A summary of the work indicates that:

When the heat is ready to be ored it contains non-metallic matter originating from the charge and from the oxidation of silicon. It is partly cleaned by the ore, but the addition of spiegel with the ore facilitates the removal of impurities.

Material coming from the bottom of the furnace under investigation was picked up during the working period. High temperature will eliminate most of this by the boiling action in the furnace. Manganese-silicon alloy followed by a small manganese addition apparently eliminated any inclusions from the above source, as well as the normal products of deoxidation.

Deoxidation with manganese-silicon alloy gives a much cleaner steel in the furnace than deoxidation by ferromanganese and ferrosilicon.

Iron oxide content of acid open-hearth steel increases gradually as carbon is eliminated. Toward the end of the working period the oxide content may hold constant or decrease, even though the carbon is dropping, due to changes in slag composition, viscosity, and temperature.

Holding the steel in the ladle as long as possible is of direct benefit in eliminating non-metallic matter. Holding the ladle of course has other advantages, in that it is better to pour the steel "on the cold side" rather than when the steel is exceedingly hot.

Los Angeles has Unique School for . . STEEL TREATERS

INNOVATIONS in administration and educational methods characterize the school for steel treaters which is being conducted by the Los Angeles chapter of the American Society for Steel Treating.

This school is designed to fill existing needs in the local metal industry. In fact, the primary cause for the educational program is the necessity for providing better materials for the drilling of deep oil wells in Southern California. Santa Fe Springs, Signal Hill and other fields were originally fairly shallow, but the discovery of new deep sands brought on a hectic program of drilling to great depths. Owing to the greater strains imposed by the deeper drilling, the old materials proved inadequate and new ones had to be provided to meet this need. Then, too, the rapid growth of the metal working industries in California has brought about a demand for more and better trained men.

A notable divergence of administrative policy from the practices of other chapters is made by the Los Angeles men. It has been usual to promote specialized educational programs through the public school system, or through some neighboring college or university. But in Los Angeles, the *entire* educational program is handled by the local chapter, through an educational committee. This group of men consists of the following: Thomas S. Hutton, chairman, Edward E. Fess, R. O. Catland, W. W. Farrar, Chester H. Dye, Prof. W. Howard Clapp, Frank C. Carter, Fred M. Arnold, J. W. Cook.

These men organize their own classes, make arrangements for the instructors, and even the text is the product of the local chapter. There was no book available that covered the ground exactly suited to the students and the metal working trades in Southern California. Therefore, the committee set to work and wrote the text for its first course. The book is entitled "A Course in Practical Metallurgy for Steel Treaters," and is printed in loose-leaf form. It was inspired by and is somewhat similar to the text prepared by the Golden Gate chapter, A.S.S.T., for the educational course started a few years earlier in San Francisco.

Some time-honored pedagogical practices have also been reversed by this Los Angeles group. In most schools, advance assignments in the text are made for study and preparation of the next lesson. Lectures and discussions are then held on the material studied. This system is reversed in the Los Angeles school for steel treaters. The students hear the lecture first, and then the loose-leaf is distributed.

T. S. Hutton, chairman of the educational committee, believes this has several advantages. First, the students give their entire time and attention to the lecture as presented by the in-

structor. If they had the lecture in hand, they might be reading it, instead of listening. And, too, the room is absolutely quiet — no rattling papers distract the attention of students or instructors. Printed material on a lecture is taken home for study. At the next session, the class assembles in three to five sections of 15 to 20 each for an oral quizz of 50 min. to an hour, covering the lecture and study material of the preceding week. Then they adjourn to the assembly hall for a new lecture.

At frequent intervals, the course is interspersed with moving picture films supplied by the United States Department of Commerce and by some manufacturers. Numerous charts provided by steel companies and furnace and equipment manufacturers are also used.

Each student pays $12 tuition, which includes the printed text. The course, as at present outlined, requires 16 weeks for completion, two-hour classes being held each Monday night. The city-owned Bureau of Power and Light provides quarters, light and power for the school.

Students come from the metal working industries, machine shops, forge plants, foundries, and rolling mills, and include some steel salesmen. They enter the school on their own volition, desiring education and advancement in the industry, and pay their own tuition. The committee does not encourage a firm to pay tuition for men in the organization.

An elementary course in fundamentals was started last year, which attracted 125 men from the surrounding territory. The chapter is continuing the elementary course this year, but limiting the registration to 50 students. It is plan-

Small Groups Are Quizzed on Text and Subject Matter Expounded in a Previous Lecture.

Students Representing All Grades From Executive to Apprentice Examine and Test Steel.

ned to offer advanced work this spring, as soon as a sufficient number of men have thoroughly mastered the fundamentals. Up to the present time, the chapter has underwritten this educational work, but it is likely that industry will be asked for assistance when the advanced work gets under way.

The faculty, consisting of Professor W. Howard Clapp of California Institute of Technology, George C. Stetter, E. E. Fess, Frank C. Carter, H. R. Abey, R. O. Catland, James H. Spade, and F. M. Arnold, was recruited from among members of the local chapter. All are experts in the fields in which they instruct. They are all volunteers. Funds remaining from tuition at the end of the season are distributed equally among the instructors, which, in most instances, covers no more than personal expenses.

Scope of Course

The scope of this course in fundamentals is indicated by the following titles:

(1) Chemistry of steel making; (2) manufacture of steel; (3) mechanical treatment of steel; (4) metallography; (5) the iron-carbon diagram; (6) micro-constituents of steel; (7) heat treating equipment; (8) pyrometry; (9) annealing and hardening; (10) case hardening; (11) alloy steels; (12) special methods of hardening; (13) testing and inspection; (14, 15, 16) laboratory exercises.

Various industries connected with the metal working trades in Southern California have warmly welcomed and enthusiastically encouraged the local chapter in its educational work. They see in it a source of men better equipped to carry out the advanced designs demanded by modern industry.

This educational work has also enthused those men who have enrolled, according to reports of officials and the educational committee. In the class work employer and employee may meet on common ground; men from different branches of the industry also meet, discuss their problems, and get better acquainted — all of which brings about better understanding and fellowship.

The morale of the individual is also raised as he finds himself better able to cope with the problems in his work. Having learned, or returned to, the habit of using some spare time in study, several men have also taken up other studies in the evening university classes in the city.

Thus the members of Los Angeles chapter, A.S.S.T., have many reasons to congratulate themselves as members of a group which meets its civic responsibilities, and which can devote a portion of its energy and resources to the improvement of the metal industry.

REVIEWS OF RECENT PATENTS

Emerald Bay, Lake Tahoe

by NELSON LITTELL
Patent Attorney
475 Fifth Avenue
Member of A.S.S.T.

Forgeable Nickel Alloys, *by John H. White, of Cranford, New Jersey, assignor to Bell Telephone Laboratories, Inc. 1,785,600; Dec. 16.*
In the refinement of nickel it has been customary to treat the molten metal with a small amount of manganese followed by a small amount of magnesium. Ingots formed in such manner are not uniformly forgeable, however.

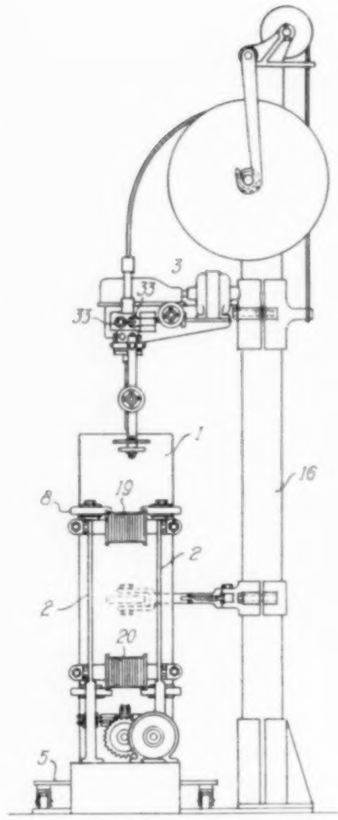
In the present invention nickel and nickel alloys are made uniformly forgeable by adding a small amount of tantalum or columbium to the molten metal as a cleansing agent. The tantalum or columbium content of the molten bath does not exceed 0.25% or 0.50%. Tantalum and columbium have a greater affinity for sulphur than has nickel and the nickel sulphide is thus broken up. These metals are maintained in molten state for a sufficient period of time for a portion of the tantalum sulphide to rise to the surface where it may be drawn off as slag. Such treatment renders the alloy highly forgeable without impairing its permeability.

Preparing Metal for Painting, *by James H. Gravell, of Elkins Park, Pennsylvania, assignor to American Chemical Paint Company, of Ambler, Pa. 1,781,507; Nov. 11.*
The patentee describes a method of pickling metallic objects in order to prepare them for painting or other applied finishes. A phosphoric acid is used for treating the metal, and in order to prevent the undue solution of the metal in the acid a neutralizing material such as di-sodium phosphate, which, although it is not a caustic material, will neutralize phosphoric acid, is used, which precipitates the metal dissolved in the acid. The precipitated metal covers the principal metal with a film which is insoluble and which tends to prevent the metal from rusting, and at the same time affords an excellent surface on which to apply various finishes such as paint, lacquer, japan or varnish.

Strain Hardening, *by Frank A. Fahrenwald of Chicago, assignor to American Manganese Steel Co. 1,784,865 and 1,784,866; Dec. 16.*
These patents relate to a method of hardening portions of manganese steel castings to increase their resistance to abrasive forces and to deformation stresses encountered in service, and particularly to hardening by localized cold working of the metal. The process consists of forming upon the surface of the steel convex elevations with spacing bearing a ratio to their radii greater than one with elevation above the ultimate general surface of the casting approximately 25% of the radii and with smooth sweeping curves of merger between the elevations. Then while the metal is becoming cooled, the elevations are depressed with resultant raising of the intermittent merging curves until a substantially smooth surface is developed. The other patent relates to a similar process in which depressions are formed in the working surface rather than elevations.

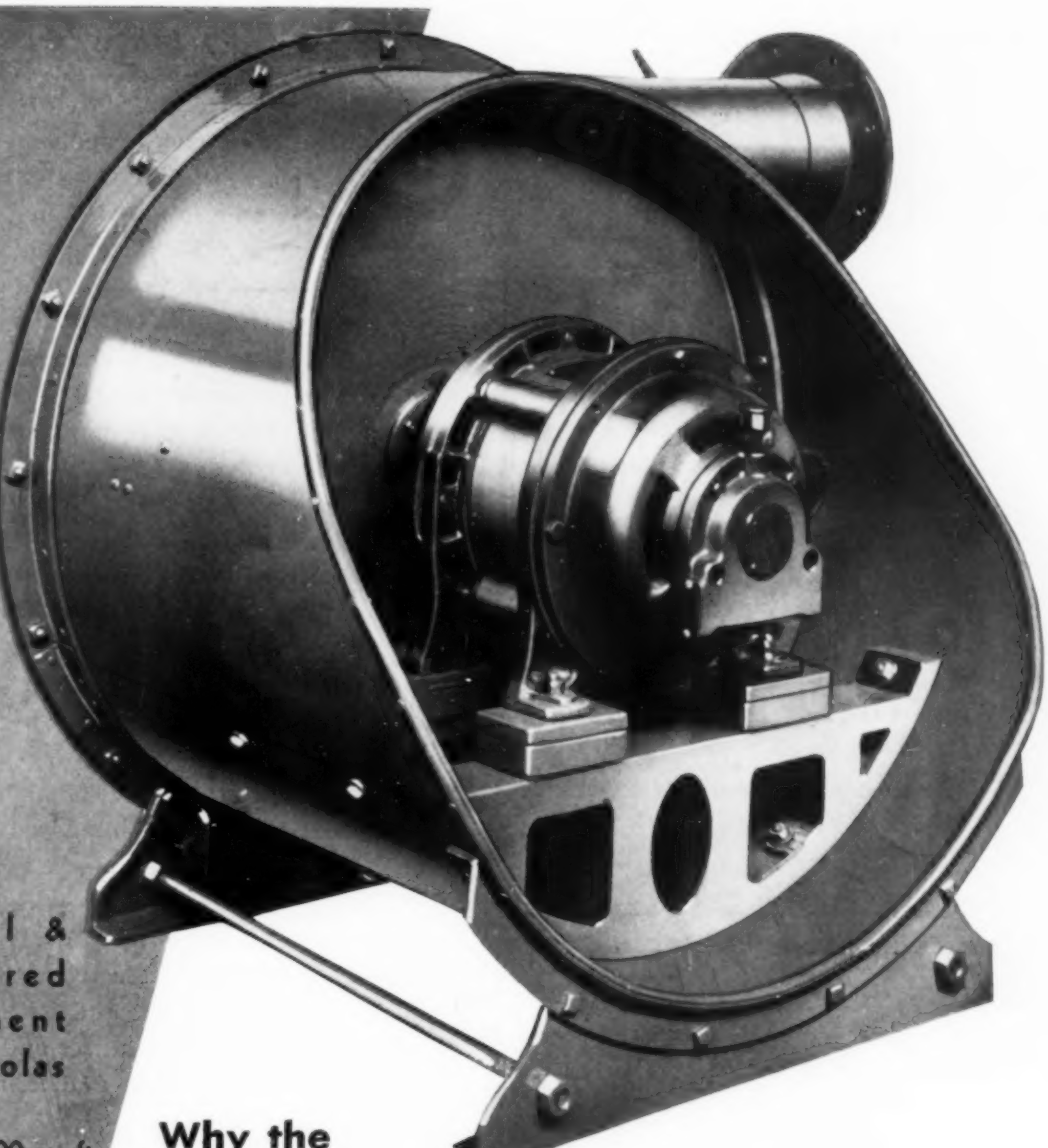
(Continued on Page 106)

Welding Machine, *by Verni J. Chapman, of Schenectady, New York, assignor to General Electric Company. 1,782,461; Nov. 25.* A welding machine for welding tanks and the like is described. It is provided with a magnetic work holder and with a suitable reel for continuous operation and welding of such articles. As shown, the work piece *1* is mounted on a caster-supported table *5*, and is rotated by a rotating device *2*, having the rolls *8*. Electromagnets *19* and *20* hold the tank against the rolls *8*. The welding means as generally referred to by the reference numeral *3*, includes an automatic head supported on a beam which is counterbalanced by a weight on post *16*, and which is provided with a feed roll *33*. When welding a circular tank, if of magnet material, the work holder is unnecessary, and only must be used when the tank is non-magnetic.



Alloy, *by Charles Philippossian, of Geneva, Switzerland. 1,783,-139; Nov. 25.*
The present invention refers to an unalterable alloy, permanently malleable and ductile, having great resistance, autogeneously weldable metal to metal, without the aid of an auxiliary metal, and readily worked hot or cold. A preferable composition contains copper, 66.5%; nickel, 18.2%; zinc, 14.5%; aluminum, 0.19%; magnesium, 0.19%; cadmium, 0.098%; silicon, 0.078%; manganese, 0.19%. Such an alloy permits clean casting of the metal, the gases being eliminated, an ideal powerful treatment as easy as, if not easier than, that of a pure metal such as copper.

(Continued on Page 112)



Nonferrous Alloy, *by Jonathan Newton White, of New York City. 1,785,372; Dec. 16.*

This patent concerns an alloy of copper, zinc and manganese in such proportions as to provide a high degree of ductility and resistance to crystallization and fatigue. Such metals are commonly employed in thermostatic apparatus for opening and closing valves, and the metal or alloy is formed into bellows or coiled so as to expand and contract with changes in temperatures. The preferable metal comprises 93 to 95% copper, 1 to 1¼% manganese, and the balance zinc.

Malleable Casting Process, *by Leslie H. Marshall, of Columbus, Ohio, assignor of one-half to Adin A. Grubb, of Columbus, Ohio. 1,781,119; Nov. 11.*

In the usual annealing treatment of malleable iron castings, there is a severe and protracted exposure to oxidizing conditions and the oxidized surface causes losses as high as 1%. In the present patent the improved process includes enclosing white iron castings in a tight bottomed container together with a substance capable when heated of evolving a non-oxidizing halogen gas heavier than air and subjecting the container and its contents to a heat treatment at temperatures and for a period of time adapted to effect malleablization.

Ferrous Alloy, *by Byramji D. Saklatwalla, of Crafton, Pa. 1,781,527; Nov. 11.*

This invention deals with a ferrous alloy containing copper, silicon, and aluminum. The copper and silicon impart corrosion resisting properties in a high degree, and particularly resistance to scaling at high temperature. The chromium can be partially eliminated and replaced by comparatively small percentages of aluminum. Such an alloy has improved rolled and forged properties and the cast materials can be subjected to annealing or other heat treating processes whereby the physical characteristics can be markedly improved. A typical alloy includes copper from 0.5% to 5%, silicon from 0.5% to 6%, aluminum from 0.1% to 2%, the carbon being in the steel range, namely; from 0.1% to 2%, or in the cast iron ranges from 2% to 3.5%.

approximately by hydrogen sulphide exposure and direct oxidation at service temperatures.

2. The resistance to this type of corrosion increases with chromium contents up to a certain point. This is particularly noticeable above 4% chromium, and is consistent with experience in service.

3. While nickel is necessary to stabilize the iron at high temperatures, it sometimes reduces the resistence to corrosion.

The effect of the addition of silicon, aluminum, tungsten and some other elements on the 18-8 steel tubes used in oil cracking stills is being studied by further tests.

Physical tests made before and after exposure to elevated temperatures, with and without corrosion, indicate considerable difference in strength and ductility in some of these alloys and little change in others. Low-carbon 18-8 chrome-nickel steel was found stable at cracking temperatures under 900° F., and under laboratory oxidation tests at 1,275° F. for 50 days. During the past year, equipment made of this steel has given excellent service, probably due to closer regulation of the still temperatures.

The changes in physical properties of the austenitic steels that occur at high temperatures are due mainly to the migration of chromium carbide to the grain boundaries and changes in the metal from the austenitic condition to ferrite. These processes may in time produce changes in ductility, strength and resistance to corrosion. The nature and characteristics of these useful alloys of steel have been clearly described by E. C. Bain in a series of articles in *Steel* commencing in October, 1930.

During the past year, considerable work has been done on those factors which retard structural changes in those metals at temperatures between 1,000° and 1,400° F. Nickel is an efficient stabilizer of austenite; 8% has been found sufficient for most purposes. Tungsten and several other elements tend to prevent the segregation of chromium carbide to the grain boundaries, with consequent impoverishment of the surrounding material in chromium. The phenomena of metallic stability and stabilization in this range of temperatures are being investigated in detail in the U. S. Steel Corporation's research laboratory and in other laboratories with promising results.

The well-known 18-8 alloy with carbon under 0.10% after water quenching from 2,100° F. is very resistant to corrosion of sulphur compounds, and has a creep value at 1,200° F. of about 9,000 lb. per sq. in. (based on 1% elongation in 10,000 hr.), which is about ten times that of ordinary carbon steel. High "creep value" and permanence of physical properties are recognized as more important for high-temperature service than resistance to corrosion. Oil refinery engineers report that the ordinary 18-8 steel has been used in regular service for over one year at tube temperatures up to 1,200° F. without excessive corrosion or impairment in physical properties.

Each Installation Requires Study

Refinery corrosion is so variable that preliminary tests are usually necessary as a guide in selecting the most economical material. The American Petroleum Institute standard method of testing should be followed. Much of the wastage at the ends of still tubes is due to erosion. This can be reduced by rolling ferrules made of 18-8 steel into the tube ends after the tubes have been rolled into the headers. Free flow headers also reduce turbulent flow and erosion. Three types of seamless steel tubes are now available for pressure stills: (a) Ordinary carbon steel of two grades (basic open-hearth and electric furnace steel), (b) the 5% chromium type, (c) the low-carbon chromium-nickel 18-8 alloy.

This review indicates that progress in combating waste has been quite considerable. However, much yet remains to be done. But the problems are recognized as of primary concern by purchasers of metal equipment. Established manufacturers are also interested and glad to work out an economical solution. This effective cooperation is the surest augury for ultimate success.

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Afloat in Bay of San Francisco

THE METALLURGICAL INDEX . . .

ABRASIVE MATERIALS

Abrasive Materials in 1929, O. Bowles. *U. S. Bur. Mines—Mineral Resources*, no. 11:7, Oct 25, 1930, 65-81.

Statistics of production, exports and imports of natural and artificial abrasives.

The Keeping Qualities of Abrasives, H. R. Power. *Metal Cleaning and Finishing*, vol. 2, no. 12, Dec. 1930, 1035-1037.

How loss of capillarity of grains having moisture, oily dust, etc., on thin surfaces may be prevented as shown by surface tenacity test.

ALLOY STEELS

Alloy Steels of Yesterday, Today and Tomorrow, E. F. Cone. *Iron Age*, vol. 126, no. 21, Nov. 20, 1930, 1485-1487.

Historical review of important development pertaining to alloy steel since 1870; introduction of tungsten steel, chromeisen, vanadium and molybdenum.

Outstanding Progress in Properties and Treatment of Alloys (Quelques Progrès importants dans les Propriétés et les Traitements des Alliages Métalliques), L. Guillet. *Revue Universelle des Mines (Liége)*, vol. 4, nos. 8 and 10, Oct. 15, 1930, 221-230, and Nov. 15, 296-303.

Review of progress in special steels; special steels resistant to high temperatures, high-speed steels; special cast irons; copper, nickel and aluminum alloys; heat treatment; chemical treatment.

Alloy Steels, C. E. MacQuigg. *Min. and Met.*, vol. 11, no. 288, Dec. 1930, 578-580.

New engineering views on old subject; railroad steels; high-chromium steels.

Comparative Physical Properties of Chromium-Nickel, Chromium-Manganese, and Manganese Steels, C. L. Clark and A. E. White. *Am. Soc. Mech. Engrs.—Advance Paper*, no. 13, for mtg. Dec. 1-5, 1930, 5, 4 figs.

Results of short-time tensile tests at 75 and 1000 deg. fahr., and creep tests at 1000 deg. fahr.; chromium-nickel steel taken from bar and tube stock, and tested in both hot-rolled and water-quenched conditions; substitution of manganese for nickel in chromium-nickel steels is detrimental, at least regarding lead-carrying ability; creep resistance of manganese and manganese-tungsten steel at 1000 deg. fahr. not equal to that type of alloy known as KA2.

TITANIUM. Determination of Titanium in Alloy Steels (Bestimmung des Titans in legierten Staehlen), J. Arend and H. Schnellenbach. *Archiv fuer das Eisenhuettenwesen (Duesseldorf)*, vol. 4, no. 5, Nov. 1930, 265-267.

Separation of titanium from all possible alloy constituents; analytical determination of gravity of titanium in purest form as titanium dioxide and colorimetric determination of isolated titanium according to Weller.

ALUMINUM

Aluminum (L'Aluminium), A. F. Pellat. *Vie Technique et Industrielle (Paris)*, vol. 12, no. 128, May 1930, 1302-1309.

General survey of history, sources, manufacture, application, consumption and future possibilities; review of principal processes for commercial production; tables give data on principal producers in various countries.

FOUNDRY PRACTICE. Strong Aluminum Castings are Obtained by Improved Foundry Practice, T. D. Stay, E. M. Gingerich and H. J. Rowe. *Foundry*, vol. 58, no. 23, Dec. 1, 1930, 72-75 and 103, 3 figs.

Paper read before Am. Foundrymen's Assn., previously indexed from Trans. and Bul., May 1930.

ROLLING. The Orientation of Rolled Aluminum, J. Thewlis. *Lond., Edinburgh, and Dublin Philosophical Mag. and Jl. of Science (Lond.)*, vol. 10, no. 66, Nov. 1930, 953-961, 7 figs.

Flat-rolling and square-rolling of aluminum; orientation determined by graphical method; square-rolled rod, if rolled from aluminum rod possessing random orientation, has same orientation as cold drawn aluminum wire.

WELDING. Electric Arc-Welding of Aluminum, F. J. Giroux. *Welding*, vol. 1, no. 12, Oct. 1930, 838 and 840, 1 fig.

Advantages of welding process with special Arcos aluminum electrode; data on current requirements. *(Continued on page 125)*

THAT ROOM

You and I as children were asked that old catch question, "What is the largest room in the world?" The answer, dripping with wisdom, is "*Room for improvement.*" We are rather proud of ourselves in one sense, for our products have made a splendid showing. But in another sense, all makers of alloy castings are so ignorant of the metallurgy of the art, so ignorant of the causes of alloy failures, that we are humble as we contemplate the long steep paths to further scientific progress.

95% of all alloy castings under heat ultimately fail not from oxidation but from "heat fatigue," the stresses of irregular heating and cooling of irregular sections under irregular loads.

None of the stress analysis data known to metallurgy, none of the "standard" tensile tests have more than a speculative connection with the phenomena of heat fatigue. Any physical data obtained at high temperature must be qualified by heating and cooling rates, applications of load, sections, primary casting strains, varying density of chill of castings, etc.

It is obvious to anyone not devoid of logic or permeated with propaganda that tensile tests made under heat, even creep tests, have small relation to the performance of even simple castings except under laboratory conditions seldom occurring in service. So superficial has been most physical testing under heat that methods of casting test bars (molding, pouring temperatures,—deoxidizers, etc.) are not standardized, seldom known.

We assume that any alterations in analysis, quality of raw materials, and the score of variables of foundry practice must be reflected in the base structure. It also follows that fatigue stresses, heat treatments and furnace atmospheres leave their microscopic marks.

We have developed methods of sample preparation to reveal base structures in complex alloys . . . are studying them at magnifications of 5,000 to 10,000.

We expect to announce metallographic discoveries which will alter conceptions and practices in the manufacture and use of complex alloys.

Our customers will receive the first benefits from such scientific advancement.

Now...As for the Past Twelve Years the best carburizing boxes are Q-Alloys

The finest carburizing boxes made, rendering lowest cost per heat hour, whether sheet or cast, are Q-Alloy . . . the largest installations, some of them totaling over half a million dollars each, are Q-Alloy boxes. . . there are those, however, who have been getting "satisfactory" service from lower grade boxes or who are influenced by first cost. . . for them we manufacture boxes of lower nickel chromium content than Q-Alloy, to proven analysis, fully guaranteed. These boxes cost no more than boxes of similar analysis manufactured by any other alloy maker. This means that you can get advantage of Q-Alloy foundry practice, Q-Alloy design and Q-Alloy service at no more than you would have to pay other makers with less experience and lower standards. *Make a note of this and buy your next boxes from General Alloys*

Benny . . . *the ruptured duck*

You may have heard our recent President of A.S.S.T., metallurgist "Peeping Bob" Guthrie, speak of a ruptured duck. This has piqued the curiosity of many a hot shot, wing and squat. With the assistance of Emil Janitzky, Prohibition Director of the A.S.S.T., we snooped. . . sought . . . pled . . . and at last produced for our readers Benny the Ruptured Duck. Now that Bob is going to South America he has consented to let us put Benny up as first prize in a brand new contest to be announced in our March issue.

GOBUS PICKS DAISIES!

And here we have Alexander Gobus, pride of American Car & Foundry, walking home from a buggy ride with a girl friend. Gobus...maidenly figure at left...was pinch-hitting for the leading lady of the Pasture Players while summering at Bustle Gulch, Ark. W-h-o-o-p-s, dearie! Who knows the little piece in white carrying the corsage of broccoli?

AN EXPERIMENT

Our mailing list for Alloys Progress is getting so large and covering so many industries, many of which are not interested in carburizing boxes, furnace parts, etc., that we are conducting an experiment in our advertising. We are running four pages in Metal Progress with equivalent space in other publications and will combine twelve to sixteen pages in a bi-monthly publication of Alloys Progress put out in several editions for various industries. (We are experimenting with this idea but may decide to put the whole business in Metal Progress. . . wait and see!)

Page II GENERAL ALLOYS CO.'S HOUSE ORGAN "ALLOYS PROGRESS"

TECHNICAL NEWS REEL

(1) The sum of $100,000,000 is spent annually on research laboratories of American industry, according to a recent authoritative estimate. Of this sum, industrial research work done by more than 600 concerns takes $75,000,000, the rest being spent by associations and bureaus. It is gratifying to note that during the recent depression, industrial research personnel, as a whole, was little affected.

(2) It will be extremely interesting to follow the trend of building design employed by manufacturing plants in the future, if the "windowless" and "all-window" structures to be built for the Simonds Saw and the Toledo Scale Companies, respectively, are fore-runners of a new era. Soon after the Simonds Co. announced that they were to have an entirely windowless plant, with artificial light, manufactured atmosphere, elaborate acoustical arrangement, and with walls, ceiling and machinery, colored with the latest in biological and psychological blues, greens, white, and orange, the Toledo people began work on a structure that is to be composed almost entirely of glass.

(3) What is believed to be the largest iron pipe ever cast is being laid under the Harlem river at 127th street and Second avenue, New York. The 614 foot conduit tunnel is to carry telephone cables, and it is estimated that 300,000 separate wires can be accommodated. The pipe is made up of two reducers, 105 to 84 in. diameter with spigot ends; light 84 in. curves 6 ft. long; and a number of 12 ft. lengths of 84 in. diameter.

(4) Surface tenacity of abrasive grains, can best be defined by forming briquettes of glue and abrasive grains—conditioning—and then pulling apart on a tensile strength machine to measure the pounds per square inch breaking strength.

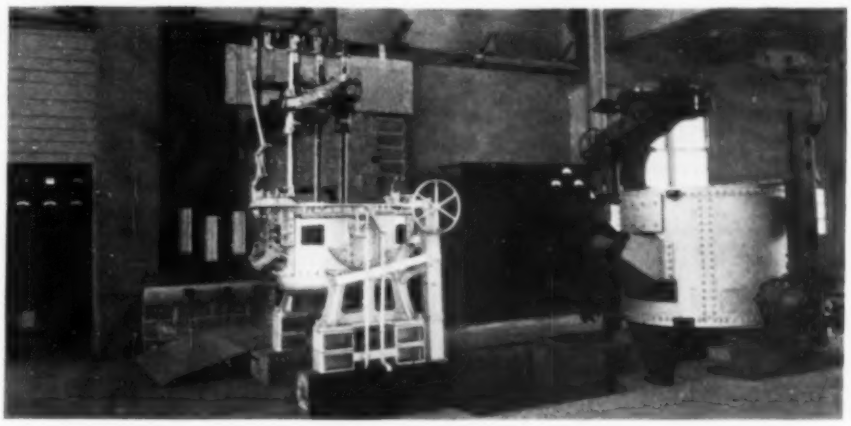
(5) And now we find that "Eighteen Eight" alloys, after extended service in the kitchen, have been promoted to the dining room. Individual tea and coffee pots, for hotel and restaurant use, are made by drawing and spinning—the handles and spout being welded on after forming operations. Material is of 24 gage.

(6) Why does the sole of one of your shoes wear out more quickly than the other? Easy! The Bureau of Standards tells us that a sole cut from the back portion of a steer's hide will last twice as long as one cut from the flank—maximum service is obtained if the portion over the kidney is specified. If this explanation isn't satisfactory, then such factors as—breed of animal, how it lived (tut! tut!), when killed, how stored, and method of tanning, should be considered.

C-O-R-R-E-C-T-I-O-N

On page 6 of our January issue under cut 4 we stated that a shaft 5 ft. long was finished to .0002″ and that another casting 4 ft. in diameter was machined and ground to .0001″. These should have read .001″ and .002″ respectively. We strive to be accurate.

New Furnaces for Our New Plant No. 2



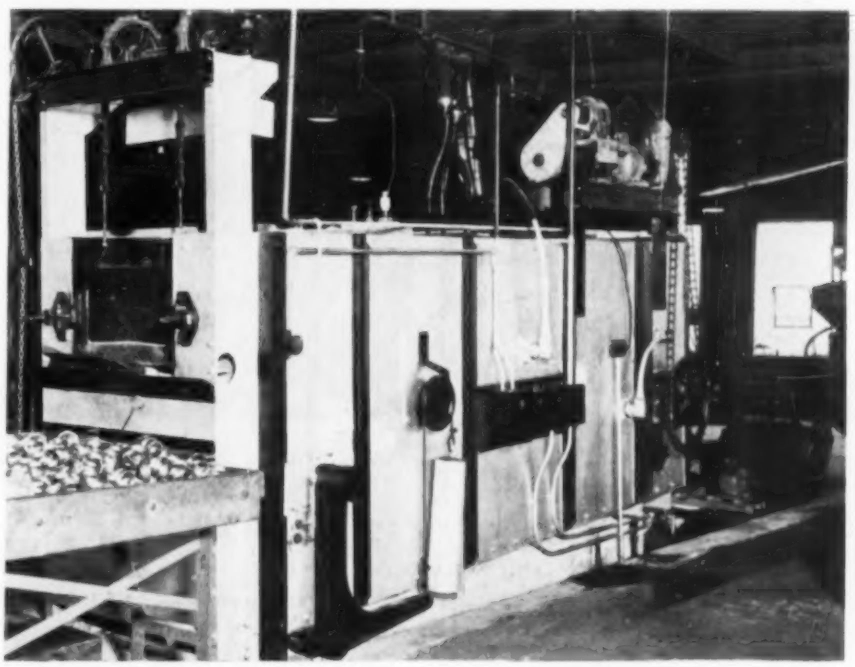
Two melting furnaces now being installed at the new General Alloys plant No. 2 at Champaign, Ill. They have 1400 lbs. and 7,000 lbs. maximum capacity respectively and are equipped with special taps and control apparatus essential to proper melting of complex alloys. A third furnace will be added. (There are three furnaces in our Boston plant.)

One reason for the metallurgical superiority of Q-Alloys is that they are not made in "one teakettle" foundries or as alternate heats in steel melting furnaces.

Cut at right shows three 800 KVA transformers, half of the new 4800 KVA substation at our Champaign plant. These knock down the juice from 33,000 to 3300. Served by three separate lines connected with four power houses.

A Thoroughly Reliable Moving Hearth Furnace... with wide range of uses...

This moving hearth furnace equipped with a continuous Q-Alloy chain belt will handle anything from stove bolts to small forgings. More than a score of these furnaces are in service, with thoroughly proven reliability, economy and versatility. The furnace shown has special equipment of continuous quenching conveyors and quenches upward of 500 lbs. of small bearing races per hour. . . . Furnaces are built in a wide range of sizes, electric or fuel-fired, by the Electric Furnace Co. of Salem, Ohio, who will be glad to send you their bulletin.



ALUMINUM ALLOYS

Light Alloys (Les alliages légers), H. Godefroid. *Revue de Fonderie Moderne (Paris)*, vol. 24, October 10, 1930, pages 343 through 346.

Review of physical properties and composition of aluminum-nickel, aluminum-silicon, and aluminum-titanium alloys; industrial applications of aluminum alloys; table gives data on electrical and mechanical properties of commercial aluminum, commercial copper and aluminum wire with steel cor

ANALYSIS. Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys. *Am. Soc. Testing Matls. — Tentative Standards*, 1930, 117-132.

Specifications cover: method, apparatus and solutions required for determination of total silicon, titanium, iron, copper and manganese.

TESTING. The Strength of Aluminum Alloy Sheets, J. S. Newell. *Airway Age*, vol. 11, and 12, Nov. 1930, 1420-1424 and 1467, and Dec. pages 1548-1551 and 1574, 22 figures.

Coordination of results of tests made at Massachusetts Institute of Technology and at Stanford University with comprehensive data obtained by U. S. Bureau of Standards, Bureau of Aeronautics of Navy Department and Material Division of U. S. Army Air Corps; results of shear or compressive tests on aluminum alloy sheets of thickness practicable for use in airplane structures use; of stiffeners and determination of shear strength.

BEARING METALS

Bearing Alloys, R. T. Rolfe. *Manchester Assn. Engrs.—Trans. (Manchester)*, 1929-1930, 13-71 and (discussion) 72-97, 42 figs.

Original of paper previously indexed from Metallurgist (Supp. to Engineer, Lond.), Jan, 31, 1930.

On the Friction and Abrasion of "The Bearing Metals", S. Kusunose. *Soc. Mech. Engrs., Japan—Jl. (Tokyo)*, vol. 33, no. 2, June 1930, 80-85, 7 figs.

Theory, equipment and methods of testing specific cases; examination of abrasion of bearing metals.

BRONZE FOUNDING

Cupola Melting of Bronze, E. R. Darby. *Metals and Alloys*, vol. 1, no. 17, Nov. 1930, 812-813, 2 figs.

Methods of operation and design of Cushing furnace used by Federal Mogul Corp., in connection with Barrett's fixed carbon fuel for melting and refining non-ferrous metals; cost approximately 12 cents per 100 lb. of metal melted.

The Founding of Bronze Gear Blanks, F. W. Rowe. *Mech. World (Manchester)*, vol. 88, nos. 2271 and 2273, July 11, 1930, 37-39, and July 25, 75-77, 8 figs.

Abstract of paper read before Inst. British Foundrymen, previously indexed from various sources.

CASE HARDENING

CARBURIZING. Thermo-Diffusion of Elements in Steel, J. Hruska. *Heat Treating and Forging*, vol. 16, no. 11, Nov. 1930, 1397-1401, 9 figs.

Investigation of mathematical relationship of percentage of migrating elements and resulting depth of penetration; tables and graphs illustrate characteristics of surface layers of carburized steel; diagram showing relationship between carbon concentration and duration of diffusion in carburizing low carbon steel; diagram showing relationship between carburizing temperature, carburizing time and resulting depth of case. (To be continued.)

CYANIDING. Cyaniding and Salt Bath Working, J. W. Urquhart. *Metallurgist (Supp. to Engineer, Lond.)*, October, 1930, pages 156-167.

Review of article previously indexed from Heat Treating and Forging, Aug. 1930.

CAST IRON

Oxygen in Cast Iron. *Metallurgist (Supp. to Engineer, Lond.)*, Oct. 1930, 152-154.

Review of researches over period of years; mechanical tests indicate that there is no relationship between oxygen content and mechanical properties; variations in these properties are due to differences in thermal treatment causing variations in graphite refinement. *(Cont. on page 126)*

Oil Hardening and Air Hardening Cast Iron, J. E. Hurst. *Iron and Steel Industry (Lond.)*, vol. 4, no. 3, Dec. 1930, 91-95, 8 figs.

Paper read before Inst. Brit. Foundrymen previously indexed from Foundry Trade Jl., Jan. 2, 1930.

Twenty Alloys for Gray Iron, E. K. Smith and H. C. Aufderhaar. *Iron Age*, vol. 126, no. 23, Dec. 4, 1930, 1688-1693, 7 figs.

Résumé of articles showing effect of additions to gray iron of such elements as nickel, nickel and chromium, silicon and others.

CHROMIUM ALLOYS

Grain Growth in the Chrome-Irons, A. Phillips and R. W. Baker. *Iron Age*, vol. 126, no. 22, Nov. 27, 1930, 1588-1589, and 1665, 2 figs.

Grain growth in high chromium heat resisting steel; data on preparation and composition of samples and method of counting grain; results are compared with work of other investigators.

Lithinit Cutting Metal (Das Schneidmetall "Lithinit".) *Zeit. fuer die Gesamte Giessereipraxis (Berlin)*, vol. 51, no. 45, Nov. 9, 1930 *(Metall)*, 181.

Lithinit is alloy composed of cobalt, tungsten and chromium as basic metals, slight amount of iron as impurity, and addition of vanadium; metal is ready for use in cast state and needs no further heat treatment; melting point is 1250 deg.; hardness is equal to that of high-speed steel.

The Structures of the High Chromium Stainless Steels and Irons, E. C. Bain. *Heat Treating and Forging*, vol. 16, no. 11, Nov. 1930, 1419-1426, 20 figs.

Paper read before Am. Iron and Steel Inst., previously indexed from Fuels & Furnaces, Nov. 1930.

COPPER ALLOYS

Copper and Copper Alloys, W. H. Bassett. *Min. and Met.*, vol. 11, no. 288, Dec. 1930, 562-564.

Broad discussion of uses of copper and its alloys under present industrial conditions.

Tentative Specifications for Sand Castings of the Alloy: Copper 80 Per Cent, Tin 10 Per Cent, Lead 10 Per Cent. *Am. Soc. Testing Matls.—Tentative Standards*, 1930, 106-109, 2 figs.

Specifications cover alloy castings, known commercially as 80-10-10, deoxidized with phosphorus.

CORROSION

Chrome Iron Indispensable in Nitric-Acid Plant, E. St. P. Bellinger. *Chem. and Met. Eng.*, vol. 37, no. 11, Nov. 1930, 691-692, 6 figs.

Report on tests of "18" chrome iron, containing low percentages of carbon, subjected to corrosion by boiling in 65 per cent nitric-acid.

Testing of Metals and Alloys to Determine Resistance to Brines (Pruefung von Metallen und Metall-Legierungen auf Widerstandsfaehigkeit gegen die Einwirkung von Salzlaugen), E. Maass and W. Wiederholt. *Korrosion und Metallschutz (Berlin)*, vol. 6, no. 10, Oct. 1930, 218-228, 9 figs.

Results of systematic studies carried out under widely different conditions to determine corrosive action of salt solutions; materials tested included sheets of iron, electrolytic copper, brass, aluminum and aluminum alloys subjected to solutions of sylvite, carnallite and glauber salt.

DIE CASTING

Die Casting (Spritzguss), A. Lion. *Giesserei-Zeitung (Berlin)*, vol. 27, no. 14, July 15, 1930, 383-385, 17 figs.

High-melting light alloys; aluminum die-casting alloys; elektron; high-melting heavy alloys. (Concluded.)

Standardized Die Casting Alloys Aid Industry, C. Pack. *Steel*, vol. 87, no. 21, Nov. 20, 1930, 55-56 and 59, 2 figs.

Analysis of factors controlling profitable manufacture; cost of metal and casting labor, operation of casting machines, trimming burden; general factory burden; general administrative and selling costs; advice for users contemplating manufacture of their own die castings. (Conclusion.)

DURALUMIN

Annealing and Hardening of Duralumin (Remarque sur le recuit et la trempe du duralumin), Matter. *Revue de Métallurgie (Paris)*, vol. 27, no. 10, Oct. 1930, 560-562, 2 figs. *(Cont. on page 130)*

venture is Forbidden

General notes on heat treatment; tempering; theory of recooling; influence of speed of cooling on mechanical characteristics.

Recent Investigations of Influence of Iron, Silicon, and Manganese on Refinement of Duralumin (Neue Untersuchungen ueber den Einfluss von Fe, Si und Mn auf die Duralumin-Veredelung), K. L. Meissner. *Jahrbuch 1930 der Deutschen Versuchsanstalt fuer Luftfahrt, E. V.*, 341-346, 3 figs.

Indexed in Engineering Index 1929, 587, from Zeit. fuer Metallkunde, Oct. 1929.

Tentative Specifications for Aluminum-Alloy (Duralumin) Sheet. *Am. Soc. Testing Matls.—Tentative Standards*, 1930, 87-89.

Specifications cover: manufacture, chemical compositions and tests, physical properties and tests, workmanship, finish, inspection.

ELECTRIC FURNACES

Electric Melting and Heating of Metals, W. S. Gifford. *Metal Industry (Lond.)*, vol. 37, no 21, Nov. 21, 1930, 481-484, 4 figs.

Review of development and use of principal types of furnaces; Ajax Wyatt furnaces; arc furnaces; induction furnaces; high-frequency induction furnaces; refractory linings; resistance furnaces; factors controlling efficiency and operation.

GASES. Artificial Atmospheres in Electric Furnaces, A. J. Strain. *Can. Chem. and Met. (Toronto)*, vol. 14, no. 10, Oct. 1930, 290-292.

Brief review of basic principles underlying oxidation and reduction of metals; factors effecting relative quantity of gases in mixture; methods and costs of producing gas for electric furnaces; advantage of atmospheres.

HIGH-FREQUENCY. High Frequency Induction Furnaces, for Making Tool Steel, J. A. Succop. *Metal Progress*, vol. 18, no. 6, Dec. 1930, 40-44, 3 figs.

Advantages in operation of induction furnaces with particular regard to Ajax-Northrup type; crucibles up to three tons capacity used satisfactorily; temperature and stirring action.

Theory and Design of the High-Frequency Induction Furnace, D. E. Lawrie. *Florida Eng. Soc.—Trans.*, 1930, 38-61, 8 figs.

Theory, design application and operation including description of research furnace constructed at University of Florida.

ELECTRIC WELDING, ARC

Application of Arc Theory on Welding (Die Anwendung der Lichtbogentheorie auf die Schweissung), D. W. Fink. *V. D. I. Zeit. (Berlin)*, vol. 74, no. 46, Nov. 15, 1930, 1557-1560, 16 figs.

Brief synopsis of theory to extent of importance for welding practice; application leads to problem of d.c. and a.c. welding and to use of plain, covered and alloy electrodes.

Shrinkage Stresses and Their Observation in Arc Welding (Ueber Schrumpfspannungen und deren Beachtung beim Lichtbogenschweissen), Lottmann. *Elektroschweissung (Braunschweig)*, no. 11, Nov. 1930, 205-214, 14 figs.

Causes and circumstances for existence and magnitude of shrinkage; practical values; hazards; characteristics of tensile and compression stresses in relation to rigidness of work piece; recommendations for control of stresses in practice.

ATOMIC HYDROGEN. Atomic-Hydrogen Arc Welding According to Langmuir System (Das Arcatomschweissverfahren Lichtbogen - Schutzgasschweissung in dissoziiertem Wasserstoff nach Langmuir), S. Sandelowsky. *Elektroschweissung (Braunschweig)*, no. 11, Nov. 1930, 215-219, 12 figs.

Principles and methods of system; its economic features compared with other systems; equipment developed by AEG in combination with I. G. Farbindustrie Works.

STRUCTURAL STEEL. American Methods of Welding Steel Structures, F. P. McKibben. *Am. Welding Soc.—Jl.*, vol. 9, no. 11, Nov. 1930, 7-18, 8 figs.

Examples of recent building totally or partially welded; saving resulting from welding; procedure control and qualification of welders; design and testing of welded joints. *(Continued on page 134)*

Abstract of paper presented before Am. Iron and Steel Inst., previously indexed from Steel, Oct. 30, Nov. 6 and 13, 1930.

STEEL ANALYSIS

Tentative Recommended Practice for Thermal Analysis of Steel. *Am. Soc. Testing Matls.—Tentative Standards*, 1930, 770-773.

Recommended practice covers: inverse-rate and differential methods; precautions that should be taken when making analyses.

CARBON. Determination of Carbon in High Sulphur Steels by Direct Combustion, H. A. Bright and G. E. F. Lundell. *U. S. Bur. Standards—Jl. Research*, vol. 5, no. 4, Oct. 1930, 943-949, 1 fig.

Oxides of sulphur are formed in direct combustion method for carbon in steel and cause positive errors if they are not removed; absorbents commonly used for this purpose, as well as promising new ones, have been tested; description is given of absorption train that has been developed at National Bureau of Standards as well as one that has been developed by Jones and Laughlin Steel Co.

INCLUSIONS. Origin and Effect of Inclusions in Steel, B. M. Larsen. *Metals and Alloys*, vol. 1, no. 17, Nov. 1930, 819-825, 3 figs.

Methods of extraction of nonmetallic inclusions; mechanical separation; extraction by differential solvent action; acid solvents; neutral solvents; effects of inclusions on properties of steel; effects of various types of impurities found in steels and their relation to phase diagrams and solubilities. (Continuation of serial.)

VANADIUM. Determination of Small Quantities of Vanadium in Steels or Alloys (Dosage de petites quantités de vanadium dans les aciers ou alliages), E. Rousseau. *Chimie et Industrie (Paris)*, Mar. 1930 (special no.), 103-112, 6 figs.

Method was developed for use as control method in steel plants; it requires about 1 hr. and is based on separation of iron from vanadium.

STEEL CASTINGS

Enlarging the Market for Steel Castings Through Engineering Research, A. Marks. *Steel Founder*, vol. 1, no. 9, Nov. 1930, 13.

Review of advantages and requirements of steel castings; production methods and applications.

A Study of the So-Called "Overreduced" Condition in Molten Steel, J. V. McCrae, R. L. Dowdell and L. Jordan. *U. S. Bur. Standards—Jl. Research*, vol. 5, no. 5, Nov. 1930, 1123-1149, 16 figs.

Study was made of four heats of acid electric steel for castings in which two heats were in so-called "overreduced" state while others were in normal condition as made according to general practice; two types were investigated as regards temperature of molten metal, structure, and physical and chemical properties.

Revised Edition of DIN 1681 (Cast Steel) [Die Neuauflage des Normblattes DIN 1681 (Stahlguss)], L. Schmid. *Maschinenbau (Berlin)*, vol. 9, no. 17, Sept. 4, 1930, 565-571, 6 figs.

German cast-steel specification revised from standpoint of manufacturer and consumer of cast steel; production methods, physical properties, composition and heat treatment.

STEEL MAKING

Removal of Last Traces of Oxygen from Steel by Means of Metallic Sodium (Sur la question du dégagement des dernières traces d'oxygène de l'acier par le sodium métallique), A. Glazunov. *Chimie et Industrie (Paris)*, Mar. 1930, (special no.) 245-246, 5 figs.

Complete deoxidation was obtained commercially at plant of Prazska Zelezarska Spolecnost, Kladno, by adding sodium in form of lead alloy, or enclosed in lead cartridges, using 100 g. sodium per ton of steel; photomicrographs showing complete absence of oxides; use of sodium increased resiliency (notched-bar test) from 9.5 to 16.0 kg. m. per sq. cm.

OPEN HEARTH FUELS. The Use of Mixed Gas (Blast Furnace and Coke Oven Gas) on Open Hearth Furnaces at Wisconsin Steel Works, G. E. Rose and F. M. Washburn. *Iron and Steel Engr.*, vol. 7, no. 7, July 1930, 394-400, 3 figs.

(Continued on page 144)

Land's End, Golden Gate

for the asking . . .

HELPFUL LITERATURE

X-Rays—General Electric X-Ray Corp. "Industrial Application of the X-Ray," a forty-page brochure explaining the value of X-rays in various industrial processes and describes the apparatus required for this work. Fifty selected radiographs are illustrated. Ask for bulletin No. E-3.

Induction Steel—Heppenstall Co. 12-page booklet describing the production of electric induction steel, illustrated. Bulletin No. E-4.

Heat Resisting Alloy—Ohio Steel Foundry Co. 20-page bulletin on Fahrite Heat Resisting Alloy, showing photographs of typical installations of this material. Bulletin No. E-7.

Buyers Guide—International Nickel Co. Buyers Guide to Nickel Alloy Steel Products. A tabulation of sources of supply for the more commonly used forged, rolled, cast or drawn products made from nickel steels and alloys. Ask for bulletin No. E-8.

Alloy Steel Handbook—Republic Steel Corp., has available a revised edition of the Agathon Alloy Steels Handbook. This contains complete instructions for the heat treatment of the various steels in chart form for easy reading. Ask for bulletin No. E-10.

Alloys—Calorizing Co. Heat Enduring, Corrosion Resisting Alloys. A technical bulletin giving physical properties of nickel-chromium iron alloys at all operating temperatures. Photographs of typical applications are included. Ask for bulletin No. E-12.

Gas Heat—American Gas Association. Send for a copy of the new book Gas Heat. No charge. Gas is now the preferred fuel for all industrial purposes. Ask for bulletin No. E-13.

Refractory Cements—Botfield Refractories Co., have prepared a 12-page booklet describing high temperature fire brick cements, including chrome cements and mixtures for surfacing and bonding fire brick in all types of furnaces. Bulletin No. E-14.

High Temperature Alloy—Michigan Steel Casting Co. A 16-page bulletin containing illustrated descriptive matter of their alloy castings and fabricated products for use in high temperatures. Ask for bulletin No. E-15.

Ingot Molds—Gathmann Engineering Co. A new book covering the subject of ingot molding. It contains numerous illustrations of the effects of various methods of finishing and casting on the reliability of steel products. Booklet C-1.

Pyrometers—Charles Engelhard, Inc. Bulletin describing features of indicating and recording pyrometers. Treats on such subjects as sensitivity, resistance, support and control of moving coil, and temperature coefficient. Bulletin E-29.

Furnaces—W. S. Rockwell Co. Booklet on Rockwell Heat Treating and Carburizing Furnaces, enclosed front type, fuel or electric, for annealing, hardening, etc. Ask for bulletin No. E-17.

Research Equipment—E. Leitz, Inc. Guthrie-Leitz Research Equipment for Grinding and Polishing of Metallographic Specimens with Automatic (Magnetic) Specimen Holder designed to operate in a most efficient manner and permitting the preparation of Metal Specimens at a minimum of expense and time. Bulletin No. E-18.

Heat Treating Equipment—Case Hardening Service Co. 24-page catalog of supplies and accessories for heat treating plants. Contains numerous illustrations and many helpful suggestions for economic heat treating and equipment operation. Bulletin No. E-19.

Heat Treating Wall Chart—Chicago Flexible Shaft Co. Chart covering temperature conversion, heat treatments for S.A.E. steels and other data for handy reference in the heat treating department. Bulletin E-28.

Ferro Alloys—Electro Metallurgical Sales Corp., has issued the third edition of "Electromet" Ferro Alloys and Metals which describes fully the products furnished by this Corporation to the various metallurgical industries. Ask for bulletin No. E-22.

Alloys—General Alloys Co., has gotten out a new bulletin on chrome nickel and straight chrome heat and corrosion resisting alloys known as bulletin E-23.

Automatic Temperature Cutout—Hevi Duty Electric Co. A new leaflet has been published describing the new "Automatic Temperature Cutout," which can be applied to any type of furnace. Ask for bulletin E-24.

Time Cycle Contactors—Automatic Temperature Control Co. Cycle controllers for the regulation of process operation are described in detail in the revised bulletin on timer application. Ask for bulletin No. E-25.

Alloys, Heat-Resisting—Driver-Harris Co. A brochure illustrating interesting Nichrome installations. Nichrome is the original heat-resisting casting. Ask for bulletin D-1.

Ascoloy 55—Allegheny Steel Co. A technical bulletin describing this chromium iron alloy will be sent on request. Ask for bulletin D-5.

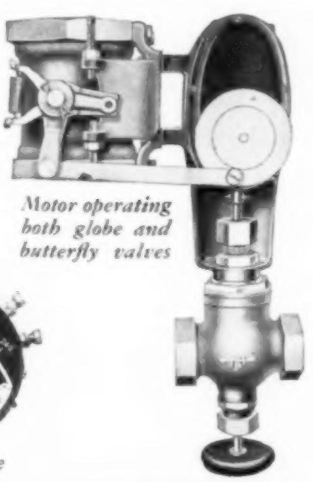
Hardness Testers—Wilson-Maeulen Co. Bulletin H-9 describing applications of the Rockwell hardness tester to a variety of types of work in many different industries. Bulletin D-7.

Hy-Ten Steel—Wheelock, Lovejoy and Co. Hy-Ten steels range in carbon from .10 to 1.00 per cent. There is a Hy-Ten grade for every vital machine part. Bulletin D-8.

(Continued on page 146)

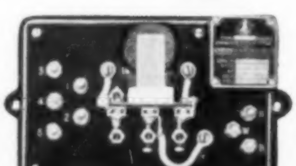
Their Wages are only $6

but what do they really *cost you?*



Motor operating both globe and butterfly valves

Temperature controller



Relay for the control of electric heaters, and of the larger motor valves

That man to whose hands you trust the temperature regulation of your furnace, vat, kiln or oven—you *pay* him, five, six or seven dollars a day, perhaps.

But what does he *cost* you in spoilage and reduced quality of your product, in wasted fuel, in extra supervision?

You will never realize how great is the waste of hand control until you have installed Minneapolis-Honeywell Regulators. Report after report from plants now operating with these dependable, accurate controls tell of fuel saved, supervising cost reduced, and uniformity and quality going up as spoilage goes down.

Minneapolis-Honeywell control systems include motorized valves which regulate temperatures or pressures by controlling the flow of gas, oil, water, air or steam. These valves operate with their own regulators or any pyrometric controller.

Our industrial representative will gladly call without obligating you in any way. Tell him your problem—he may help uncover hidden profit losses for you as he has for others.

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☐ Have representative call. I understand there is no obligation.

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Company..
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Experiences of actual operation show advantages of movable gas port when working on mixed gas; tables give data on cost of brick repair for gas and oil-fired furnaces; graph illustrates transfer of heat from burning of preheated gas to cold walls; details on economy.

OPEN HEARTH SLAG. Laws Governing Composition of Basic Open-Hearth Slags (Gesetzmaessigkeiten in der Zusammensetzung basischer Siemens-Martin-Schlacken), S. Schleicher. *Archiv fuer das Eisenhuettenwesen (Duesseldorf)*, vol. 4, no. 5, Nov. 1930, 239-242 and (discussion) 243-244, 8 figs.

Based on series of slag analysis, laws governing chemical composition of open-hearth slags are made clear; degree of manganese content of slag is greatly dependent upon calcium-oxide and magnesium-oxide content, and that iron content decreases with increasing content of silicic acid and phosphoric acid; slag composition can be calculated on basis of iron and manganese content.

REFRACTORIES. Care and Maintenance of Fuel-Fired Furnace Linings in the Nonferrous Foundry, H. E. White. *Am. Foundrymen's Assn.—Trans. and Bul.*, vol. 1, no. 11, Nov. 1930, 644-653.

Refractories in various types of open-flame furnaces and nonferrous melting cupola; 1926 and 1929 surveys show, decrease in use of fireclay refractories and increase in silicon-carbide and alumina-silica, mullite and aluminum-oxide types; causes for failure; proper installation drying and glazing.

STEEL TESTING

Acceptance Tests of Gear Steel. *Metal Progress*, vol. 18, no. 6, Dec. 1930, 91-94, 4 figs.

System of steel inspection of Brown-Lipe-Chapin, with particular regard to cleanliness, normality, grain size and hardenability; data on compensation and deep etch test.

Wear of Automobile Parts and Means of Reducing Wear (Verschleiss an Automobilteilen und Mittel zur Verschleissverminderung), E. Franke. *Automobiltechnische Zeit. (Berlin)*, vol. 33, no. 32, Nov. 20, 1930, 768-771, 12 figs.

Effect of oxygen content of air; wear testing method by means of M. A. N. machine type Spindel; characteristics of manganese steel, chromium nickel steel, and other steels with satisfactory wear resistance.

Tungsten-Carbide in the Westinghouse Plant, J. M. Highducheck. *Machy. (N. Y.)*, vol. 37, no. 4, Dec. 1930, 259-261, 3 figs.

Directions for obtaining best results with new tungsten carbide cutting tools in regular machine shop practice; differences in application of tungsten-carbide and high-speed steel tools; brazing tungsten-carbide tipped tools.

LAPPING. The Lapping of Tungsten-carbide Tools. *Machy. (Lond.)*, vol. 37, no. 945, Nov. 20, 1930, 245, 2 figs.

Procedure in lapping tungsten-carbide tools with abrasive compound developed by Carborundum Co., Ltd., for fast and inexpensive lapping; speed of from 900 to 1200 surface ft. per min.

TESTING. Cutting Tests with Cemented Tungsten Carbide Lathe Tools, T. G. Digges. *Mech. World (Manchester)*, vol. 88, no. 2288, Nov. 7, 1930, 443-444, 3 figs.

Abstract of paper previously indexed from U. S. Bur. Standards—Jl. Research, Aug. 1930. (To be continued.)

TUNGSTEN CARBIDE

Cutting Tests with Cemented Tungsten Carbide Tools, T. G. Digges. *Metals and Alloys*, vol. 1, no. 17, Nov. 1930, 836-839, 11 figs.

Abstract of paper read before Am. Soc. Mech. Engrs., previously indexed from Advance Paper, June 9-12, 1930, Engineer, Sept. 5, 1930, and U. S. Bur. Standards—Jl. of Research, Aug. 1930.

Cutting Tests with Cemented Tungsten Carbide Lathe Tools, T. G. Digges. *Mech. World (Lond.)*, vol. 88, nos. 2289 and 2290, Nov. 14, 1930, 457-459, and Nov. 21, 481-483, 12 figs.

Abstract of paper previously indexed from U. S. Bur. Standards—Jl. Research, Aug. 1930. (Concluded.)

(Continued on page 162)

Helpful Literature Continued.

Fatigue Testing Machine—Thompson Grinder Co. A bulletin describing the rotating beam type fatigue testing machine. Giving interesting data on fatigue testing. Bulletin D-9.

Chromel Resistance Wire—Hoskins Mfg. Co. Catalog and handbook describing Chromel resistance wire and other resistance alloys, also thermocouple alloys, giving technical information and data. Bulletin D-10.

Globar Heating Elements—Globar Corporation. Bulletin "Globar Non-Metallic Electric Heating Elements" which gives the physical characteristics and applications of Globar elements. Bulletin D-12.

Tool Steels—Carpenter Steel Co. Bulletin "Timbre and How It Affects the Properties of Carbon Tool Steel." Defines Timbre and illustrates and describes Timbre testing. Published by the research department. Bulletin C-6.

Deoxidizers—Vanadium Corp. of America. Leaflet describing Alsifer, a material used for the deoxidation of steel during manufacture. Ask for bulletin No. B-6.

Corrosion and Heat Resisting Steels—Colonial Steel Co., Vanadium Alloys Steel Co., and Anchor Drawn Steel Co. Booklet gives complete data regarding stainless A, stainless B, stainless I, stainless FMS, stainless N, stainless U and stainless CNC. It is intended for shop men to whom it gives valuable technical information. Ask for bulletin No. B-4.

Heat Treating Chemicals—Roessler and Hasslacher Chemical Co. Booklet "Case Hardening and Heat Treatment of Steel." Comprehensive data on cyanides for surface hardening, physical properties and methods of use of salt baths for drawing, annealing and general hardening. Ask for bulletin No. B-13.

Fuel Fired Furnaces—Electric Furnace Co. Eight-page bulletin illustrating oil and gas fired continuous and batch type billet heating, forging and car type furnaces for heating, normalizing and heat treating, also labor saving material handling equipment. Ask for bulletin No. B-18.

Nirosta Buyers Guide—Krupp Nirosta Co., Inc. A concise listing of Companies, producing Nirosta metal, their addresses and the forms of material they are prepared to furnish. Ask for bulletin No. B-19.

Furnaces—Strong, Carlisle and Hammond Co. invites your requests for their bulletins and reprints of recent furnace installations. Your inquiries are solicited. Ask for bulletin No. B-20.

Industrial Regulators—Minneapolis-Honeywell Regulator Co. Booklet describing their motorized valves used in furnace temperature regulation. These valves operate with their regulators or with any pyrometric controller to regulate flow of gas, oil and air. Bulletin F-20.

Resistance Thermometers—Leeds and Northrup Co. Revised catalog treating in detail resistance thermometers for recording, controlling and indicating temperatures, covering heating and ventilating, applications in refrigeration and chemical plants, gas-making and other low temperature applications. Bulletin F-19.

Steel Handbook—Jos. T. Ryerson & Sons, Inc. Handbook on Tool and Alloy Steels. Description, technical data and general information on tool and alloy steels. Also nontechnical description of heat treating methods and shop practice applying to various steels. Bulletin F-18.

Induction Furnaces—Ajax Electrothermic Corp. This bulletin gives latest information regarding coreless induction furnaces in capacities up to several tons, and motor-generator equipments for energizing the furnaces. Bulletin F-17.

Scale Prevention—Dearborn Chemical Co. Booklet describing latest scientific methods of treating water for prevention of scale, corrosion and foaming in steam boilers, dealing with related problems in connection with scale and corrosion in other power plant equipment. Bulletin F-16.

Rotary Hearth Furnaces—George J. Hagan Co. Bulletin covering various rotary-hearth type furnaces built and installed by this company. Bulletin includes photographs of typical installations. Bulletin F-13.

Pickling Equipment—Weaver Brothers Co. Bulletin on Weaver-built Monel metal pickling equipment showing baskets and crates designed to meet every pickling need. Bulletin F-14.

Handbook—Columbia Tool Steel Co. Tool Steel Handbook containing valuable information on the making of tools, heat treating, application of steels, tables of information, etc. Bulletin F-15.

Resilia—Bethlehem Steel Company has published a folder describing Resilia, a silicon-manganese spring possessing great strength, lasting resilience, and remarkable fatigue resistance. Bulletin F-12.

Leitz Metallurscope—E. Leitz, Inc. Serving for microscopical examination of metal specimens in laboratories and work shops. This instrument is of portable construction and can easily be transferred from one plant to another. Bulletin F-11.

Oil Burners—Ryan, Scully & Co. Booklet on low pressure automatic oil burners, completely describing and illustrating this type of burner installation. Booklet F-5.

Heat Treatment—"Houghton's Liquid Baths for the Heat Treatment of Steel." E. F. Houghton & Co. 158 page book, profusely illustrated and covering subjects of hardening and tempering, surface hardening, decarburization, deterioration and furnaces. Bulletin F-10.

Furnaces—Surface Combustion Corporation invites your request for the following new bulletins: Cauldron Furnaces and Solution Heaters F-7; Soaking Pits, F-8; and Roller Hearth Annealing Furnaces F-9.

Furnaces—American Electric Furnace Co. has a new bulletin covering carburizing and annealing furnaces in the 36" and 48" widths. A request for bulletin F-6 will bring immediate response.

Heating Machines—American Gas Furnace Co. Bulletin describing and illustrating latest developments in economical heating machines for heat treatment, case hardening, coloring, brazing, etc. Bulletin F-4.

Economical Heat Treatment of High Speed Steel—Thwing Instrument Co. Thwing radiation pyrometers measure temperature of steel itself in furnace while being heat treated. No temperature lag. No deterioration. No part of radiation pyrometer goes into furnace. Outlasts thermocouple pyrometers. Maintenence cost negligible. First cost practically last cost. Bulletin F-3.

Electric Heating Equipment—Westinghouse Electric & Mfg Co. 100-page catalog covering industrial heating equipment. Publication includes operating data, charts, tables and installation photographs in addition to specifications and illustrations of industrial heating equipment. Bulletin F-2.

Aluminum Alloy Castings—British Aluminium Co. Ltd. Booklet contains information on aluminum alloys used in all manner of light alloy castings. Contains a quantity of technical information for foundries and users of aluminum alloys and alloy castirgs. Booklet F-1.

Metal Progress, 7016 Euclid Ave., Cleveland.

Please have sent to me the following literature as described under "Helpful Literature for the Asking" in February Metal Progress. (Order by number.)

....

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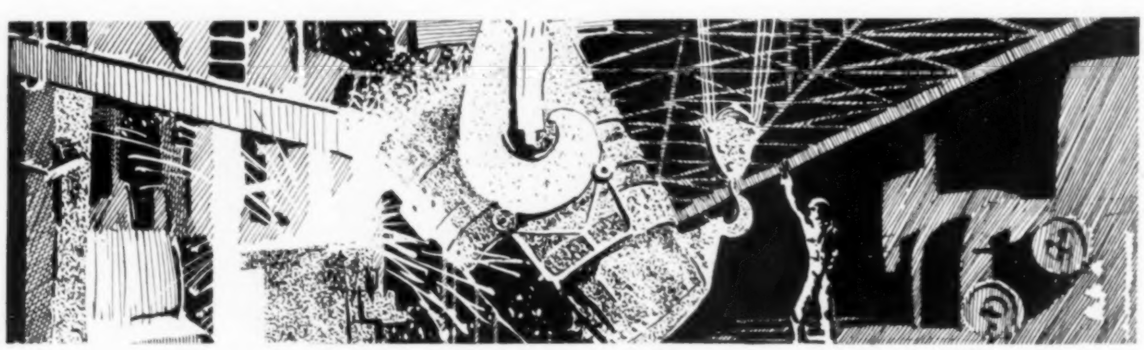
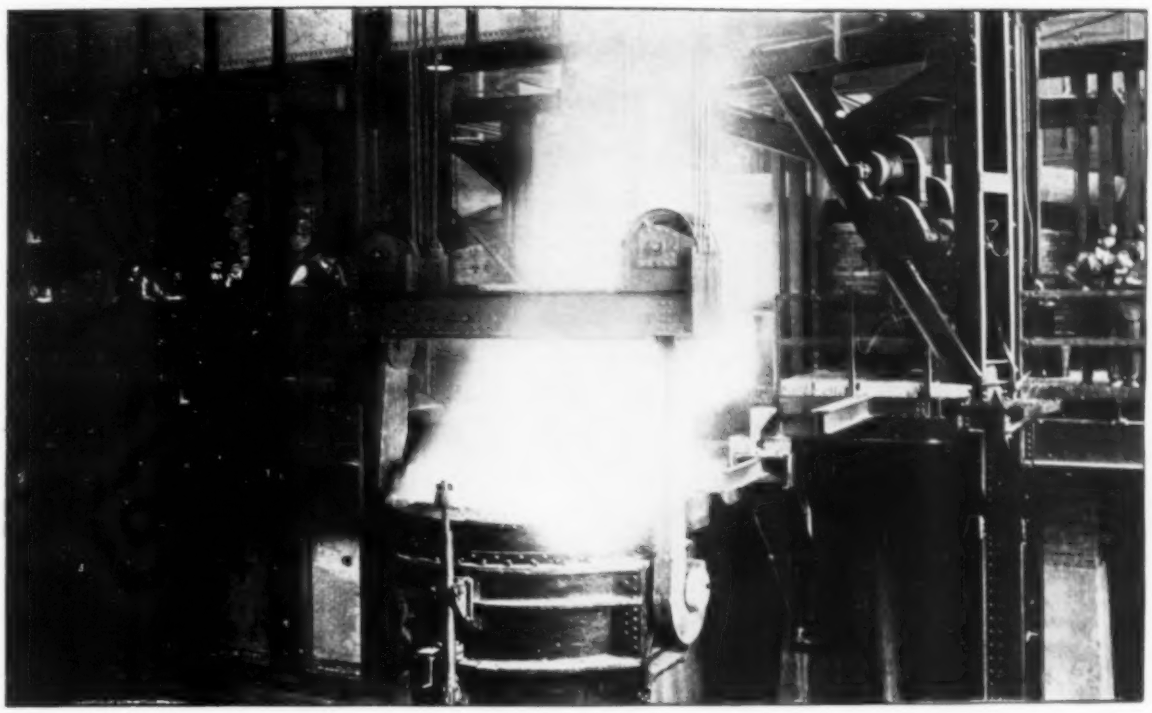
welding, foundry work, and other mechanical operations. It is management's job to make operations fool-proof so far as possible, and, whenever practicable, to provide equipment to do a stated task at a predetermined time, always in the same manner and under a given set of conditions.

Welding proponents might well ask: "Does the manufacturer of steel castings afford the security caused by any such mechanical regulation?" The user of materials which might be either steel castings, forgings, rolled shapes, or welded fabrications may appropriately make such an inquiry. Obviously, the answer of an honest steel foundryman cannot be completely affirmative. The limitations of the art of founding involve the personal element to a considerable degree, but not, fortunately, to the extent that prevailed before the advent of the present century, as the writer happens to remember. The degree to which soundness and all other desirable characteristics of a steel casting may be conservatively expected is dependent to a very large extent on the number of pieces to be made from a pattern. This, of course, is inseparably related to the matter of suitable pattern and other equipment. That is a factor that governs the practices capable of application by the superintendent for the most effective production of the job. In almost every industrial field quantity production lends itself to quality output. This does not happen to be true where plants are not equipped so as to take economic advantage of the manufacture of parts required in large numbers. It is in the production of multiple pieces by methods employing mechanically regulated welding for fabrication, where one may look naturally for partial restriction of the personal equation in such assembling manufacture.

Some things we have pointed out are fundamental principles, recognized by industrialists generally, but sometimes they are forgotten in the enthusiasm created by advocates of a special process. Only by the removal of prejudice, the elimination of exaggerated claims, and the study of the underlying factors, can sensible deductions be drawn. When these are made after comprehensive analysis of the problem as to the material and the conditions of service, the steel casting (like any other metal part that may be under consideration) should take a front, an intermediate, or a rear rank in the advance of any consuming industry.

May we say finally and with becoming modesty (and in the light of current industrial history) that the steel foundry, in the face of aggressively stimulated competition, is being depended on yearly with greatly increasing confidence to meet service conditions of the most exacting character. The industry feels justly proud of its achievements. It has a great deal to do before it can approach closely that perfection which is the objective. And the men who are identified with the industry display a determination to install more effective methods in a way that makes many, including the writer, glad that they happen to be steel foundrymen.





Nitriding Furnace

The volume control for gas and air is operated from a solenoid and in turn is actuated by a potentiometer type controller. It varies the amount of gas and air supplied to the burners, and therefore, the input of heat to the furnace. The actual control of the temperature at which the furnace will operate is obtained by the amount of cold air which passes through the system and dilutes the above-mentioned fuel supply. This can be controlled by a small blast gate and a manometer. If we find that to hold a temperature of 450° F. requires an amount of air passing through the system which gives a pressure of $6\frac{1}{2}$ in. on the manometer, we then know that to reproduce this temperature we must set the diluting air at the same manometer pressure. It is a very simple matter to calibrate the scale for the various temperatures. The furnace can be operated satisfactorily at temperatures as low as 300° F., and as high as 1,200° F., with close regulation of temperatures and very nearly uniform distribution of heat.

The view on page 39 shows a load of parts for drawing. The truck is of heat-resisting alloy. At other times the truck would be loaded with a nitriding box. We have had good results with a box sealed with lead or solder.

Inlet and outlet pipes for the nitrogen may best pass through the rear wall of the furnace, where they are connected by suitable flexible leads to the bubble bottle for the inlet and to the exhaust pipe for the outlet.

As the nitriding operation is a long one, safety devices should be supplied on the gas line, so that should there be any interruption of gas or air blast, the gas line would be automatically closed. These precautions must be taken because the combustion chamber does not rise to the ignition temperature of gas when the furnace is operating at 1,000° F. or lower. The furnace shown in the illustrations on pages 38 and 39 has been in operation over a period of six months, doing nitriding work the majority of the time, and in all that period was shut down automatically only once.